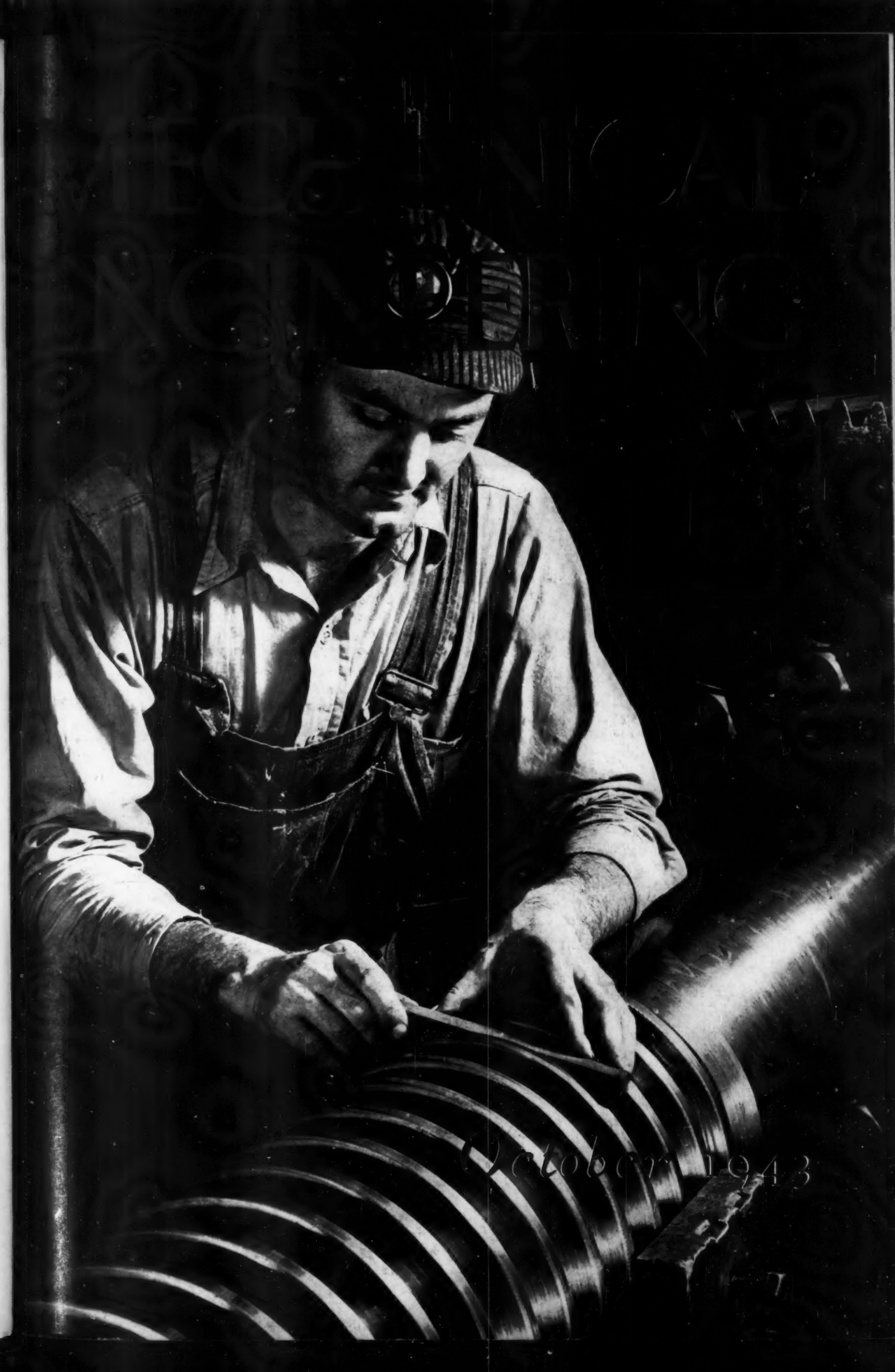
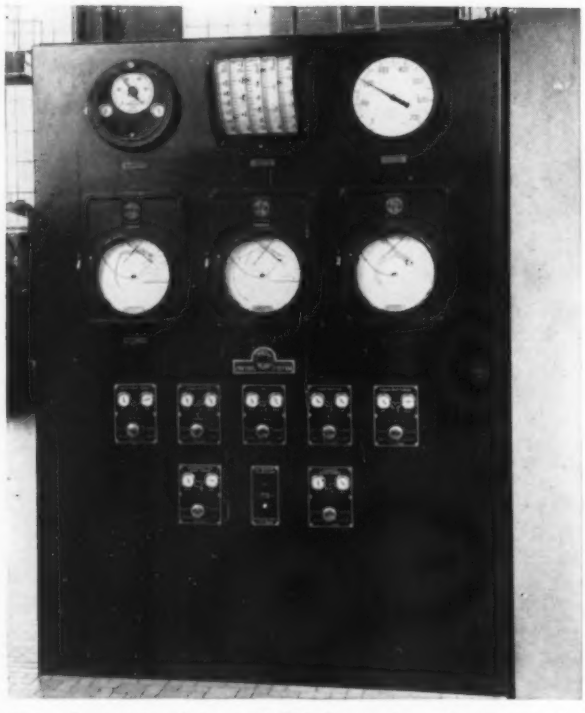
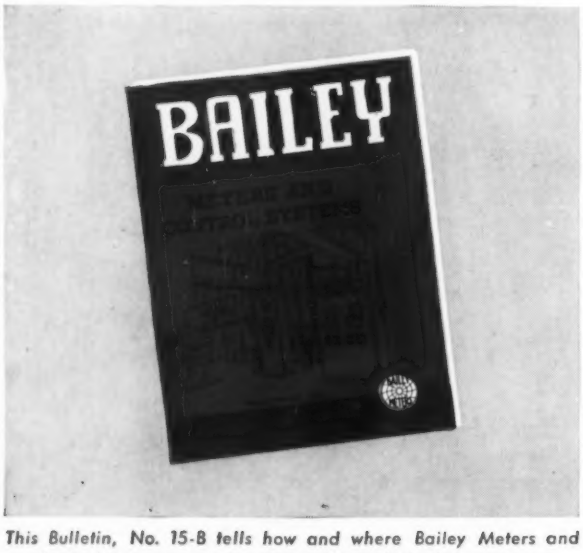

October 1943

A Service FOR BETTER POWER PLANT PERFORMANCE



Bailey Control Panel for a 60,000 lb. per hour Gas-fired boiler in a Mid-west power plant.



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MECHANICAL ENGINEERING

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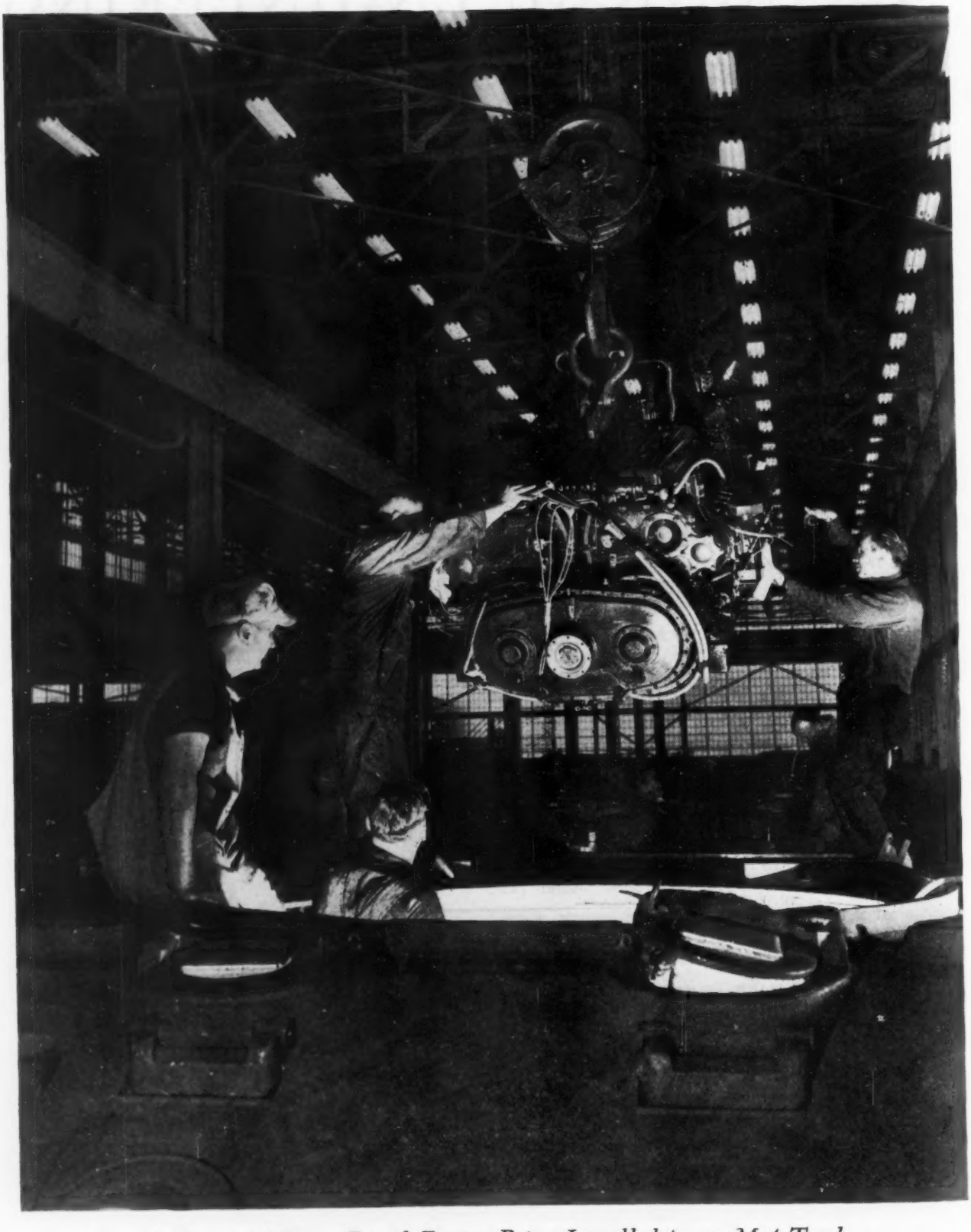

A General Motors Diesel Engine Being Installed in an M-4 Tank

VOLUME 65
No. 10

MECHANICAL ENGINEERING

OCTOBER
1943

GEORGE A. STETSON, *Editor*

Patent Legislation

A FEW months ago Dean A. A. Potter, past-president of The American Society of Mechanical Engineers and executive director of the National Patent Planning Commission, summarized in MECHANICAL ENGINEERING the recently issued report of that Commission. It has been rather generally agreed that this report represents a fair and constructive view of the American patent system and that the recommendations of the Commission are worthy of serious consideration. What will come of the report in the way of legislation is a responsibility of the Congress and the enlightened support of the American people.

By the time the October issue of MECHANICAL ENGINEERING is in the mails, the Congress will have reconvened after its summer recess and one or more bills relating to changes in the American patent system may have been introduced. It is probable that these bills will represent a wide variety of views on what changes in the system should be made. Some of the suggestions will be in line with those of the report; others may be ill-considered and harmful to the best interests of the nation. Intelligent appraisal of all suggestions with vigorous support of those which will correct some weaknesses without destroying the powerful influence which our patent procedure has had in our industrial and free-enterprise traditions will be urgently needed.

No group of citizens is as vitally concerned with the American patent system as is the engineering profession. No group is more competent than it is to weigh proposals, support those that are constructive, and oppose those that are definitely harmful. Fortunately, the form of government under which we live provides means by which the individual citizen or a group of citizens may make its opinions known to those whose duty it is to write the laws. Not to take advantage of these means is to let a vital issue go by default.

It would be a serious mistake, however, to assume that the public in general has no stake in changes in the patent system. Students of patent systems, our own and those of other nations, have testified for generations that the foundations of our industrial supremacy and of individual incentive are strongly buttressed by our patent system. Because of the American patent system we as a nation enjoy a standard of living, and in normal times a degree of individual and collective prosperity, beyond anything that has ever been found elsewhere in the world. While temporary and isolated cases of unemployment or reduced earnings can be cited as the results of economic and social changes caused by the obsolescence of products and skills, the net result of these changes has been to increase wealth, opportunity, and the general standard of living. To make these facts clear to their fellow citizens and to make clear also the constructive and destructive possibilities of suggested changes in the American patent system so that laymen may be able to write intelligently to their Congressmen is a very serious obligation which rests on mechanical engineers.

Voice From China

LAST spring, Paul B. Eaton, member of the Council of The American Society of Mechanical Engineers, went to China as a special representative of the Department of State to assist the people of China in some of their technological problems. Armed also with credentials from the Society and bearing messages of encouragement and good will, Mr. Eaton became a point of contact between the engineers of China and those of this country. On June 6 at Chungking on the occasion of China's "Engineers' Day"—a day set aside by the government of China in honor of the first Chinese engineer, Ta Yü—Mr. Eaton broadcast his messages of greeting and thus made public to the people of China the friendly interest which engineers in this country have in them.

Friendly interest, however, is cold comfort for a nation overrun with foreign soldiers and facing, after victory is achieved, a stupendous task of reconstruction and economic development. A freed and reawakened China needs more than friendly interest in its predicament and future. It needs, among other things, the know-how of the modern industrial world which is based so importantly on engineering and technology. This America has in abundance. To share and to instruct are opportunities which pave the way for world peace and bring reciprocal advantages to us.

It will interest readers to know that, in addition to what our government is doing for China in the prosecution of the war, it is making a small start in providing Chinese engineers with engineering literature. Through the Division of Cultural Relations of the Department of State and with the consent of the engineering societies involved, microfilm copies of the publications of our societies are regularly being forwarded to China. Among these are the A.S.M.E. Transactions, including the *Journal of Applied Mechanics*. It is hoped that eventually MECHANICAL ENGINEERING will also be sent to China in microfilm form.

A recent letter from Mr. Eaton mentions two ways in which engineers in this country can help China and her engineers. One is immediate; the other must await the coming of peace. The more distant means of aid may be rendered by American engineers and technicians who may be induced to assist in the rehabilitation of China.

At the present time China is sending to this country

groups of engineers and technicians to be trained for eventual service at home. The need for the know-how in such fields as manufacturing and railroading, for example, is desperate in China. In addition to the top managerial and engineering groups which are essential for the success of enterprises, large numbers of foremen are necessary. Some industries in this country are already making arrangements to open opportunities for foremen training to technicians from China. This important movement would be greatly speeded if other industries would volunteer to take Chinese technicians for foreman training. It should not be too difficult for alert industrialists to visualize the reciprocal advantages of taking part in this training program.

A Super Society?

IN the *A.S.M.E. News* section of this issue readers will find that the President's Page contains an announcement of the formation of a committee to report to the Joint Conference Committee, consisting of the presidents, junior past-presidents, and secretaries of the Founder Societies and the American Institute of Chemical Engineers, on the frequently discussed question of engineering-society co-ordination.

Plans for establishing a means by which the entire engineering profession can find solidarity and a voice to express its opinions through co-ordination, which might take the form of some super society, have been discussed throughout the years and, from time to time, attempted in one way or another. One of the results of the last war, when this apparent lack in the engineering profession was acutely recognized, was the formation of the Federated American Engineering Societies which was later modified and known as the American Engineering Council. After many years of service in which the Council had its ups and downs it was finally dissolved. Other attempts at joint action of the engineering societies are still in existence, for example, the United Engineering Trustees, the Engineering Societies Library Board, the Engineering Foundation, and the Engineers' Council for Professional Development. None of these in its present form, however, meets the needs that proposers of a super society have in mind. Apparently, the committee announced by President Coes is to review the question afresh.

The subject is one in which every engineer has a vital stake. In spite of past failures and disappointments, in spite of apathy, in spite of honest differences of opinion there would seem to be no reason why engineers should not be successful in perfecting some inclusive organization through which the desired co-ordination and solidarity could be achieved. That it will take time none will deny, but many able men have studied the subject, many plans have been proposed, and there is precedent in other professions that offers encouragement.

It will be recalled that a few years ago when the question was being agitated in The American Society of Mechanical Engineers, W. L. Batt pointed out that pressure from the rank and file for the desired co-ordination was more likely to result in a solution than would waiting for the matter to be imposed from the top by governing bodies. The present attempt appears to have this policy in mind because Mr. Coes earnestly solicits, on behalf of the committee, the views and assistance of all members of the A.S.M.E. If a super society or some other means by which greater co-ordination can be brought into the engineering profession is really desired by members of the profession, the stage is set for its consideration. If such an organization is to be a success it will demand the active and constant support of all concerned and a considerable amount of patience and compromise during the early stages of its development.

Centenary

IN September *The Economist* (London) celebrated its one-hundredth anniversary. Although this famous weekly newspaper is better known in financial and business circles than it is among engineers, it is appropriate for engineers to offer congratulations to its editors. Year by year engineering draws ever closer to the realms of finance and business. In recent years engineers in this country have experienced an awakening to the economic and social factors of their communities, their nation, and the world at large which has expanded their interests into the fields which *The Economist* serves. Those fields include some aspects of the engineer's own, if not the highly technical ones so ably served by our British contemporaries, *Engineering* and *The Engineer*. Indeed, much that the editors of these engineering weeklies discuss with their readers is discussed also in the pages of *The Economist*.

Just as it is to the advantage of the engineer in this country to read what the British weeklies have to say about engineering matters, so is it also to their advantage to get the point of view of such journals as *The Economist* on subjects in the field of business, economics, social and labor problems, and industrial questions which, if not identical with those in this country, are sufficiently similar to be helpful and broadening.

It is much easier to think objectively about our neighbors' problems than it is about our own and there is always a chance that such thinking may enlarge perspective and suggest solutions. Education, the coal-mining industry, labor unions, labor-management committees, international trade, shipping, air routes, free enterprise, social security, postwar planning, production, and a host of other topics belong to the problems and thinking of no one nation. They are all part of the engineering industrial economy in which we live and with which engineers have a major concern.

It is helpful also, and acknowledgment is here made for help received, to read the comments of others on our own affairs, whether or not we can agree with the opinions expressed. Illuminating also is it to read thoughtful views and explanations of events and conditions in other countries—Europe, South America, and the Orient, for the fare is varied and extensive. Best of all, in many ways, is the lucid, forthright, and arresting manner in which *The Economist* reports its news and expresses its opinions. As the second century begins, readers of *The Economist* in this country will continue to look forward to their weekly quota of intelligent appraisal and thought-provoking comment.

MACHINE SCREWS

Fastening Strengths in Various Materials

By A. C. MILLARD

MEMBER OF TECHNICAL STAFF, BELL TELEPHONE LABORATORIES, INC., NEW YORK, N. Y.

ALTHOUGH standard machine screws in the numbered sizes have been widely used as fastenings for many years, very little has been published concerning their strength of fastening in various metals and nonmetals. Numerous articles have appeared regarding the strength of bolts and machine screws for 1/4 in. and larger sizes, but very little, if any, published information is available on the strength of machine-screw fastenings in the numbered sizes.

The need for machine-screw fastening-strength information has increased recently due to the use of more compact designs and the shortage of materials. The use of substitute materials has accentuated the lack of machine-screw fastening-strength information in making fastenings in such materials, as well as in the more commonly used materials. Frequently, it is desirable to know the load-carrying capacity of screw fastenings of various diameters, as well as the length of thread engagement in the weaker materials needed to develop either the full strength of the screw, or the strength of fastening required of the assembly. The purpose of this paper is to make available to designers the results of fastening-strength tests of machine-screw fastenings in a number of materials, which were carried out by the author at the Bell Telephone Laboratories, Inc. The work is by no means complete but it is hoped that the data offered will prove to be of some use in its present form.

FIVE TYPES OF STRESS TO CONSIDER

In modern design it is often necessary to take full advantage of the available strength of screw fastenings and thereby reduce weight and size as much as possible. Intelligent use of screw-thread fastenings requires consideration of five types of stress, namely, (1) torsion, (2) tension, (3) impact, (4) shear, and (5) fatigue.

These stresses should be considered not only in their relation to the function of the complete apparatus, but with respect to the assembling of the apparatus in manufacture, as well. The data on the accompanying charts portray the strength of selected sizes of rolled-thread machine screws in several lengths of tapped holes in various metals and nonmetals, subjected to tension, torsion, impact, and shear. Each value given is the average of at least five determinations. The screws and the associated tapped holes assembled in the test all met Class 2 fit requirements.

No data are reported on fatigue of machine screws in the small sizes. Information of the effect of fatigue on large-sized screw threads has been published from time to time. A summary of the literature on the subject was published recently.[1]

EQUIPMENT AND CONDITIONS OF TESTS

The torsion values were determined on a pendulum-type torsion-test machine, shown in Fig. 1, which was built for this purpose. The load was applied at a rate of 1 1/2 rpm. The screws were assembled in a hardened-steel fixture, using a tapped hole in the material under test as a nut. The nut was held in a calibrated fixture which resisted the twist, while torque was applied by a screw driver to the head of the screw. The test was continued until the fastening failed either by stripping of the nut, stripping of the thread of the screw, or the breaking of the screw.

In using the torsion-test data, consideration must be given to the length of the screw thread engaged, and to the material and finish of both the screw and the material in contact with the head of the screw.

In using a screw-and-nut combination as a clamping medium, friction is developed between the head of the screw and the surface upon which it bears, as well as between the threads of the screw and the threads of the nuts. The value of the force required to overcome the friction under the head of the screw depends upon the additive finish on the surfaces involved and the smoothness of these surfaces. The value of the force required to overcome the friction between the threads of the screw and the threads of the nut also depends upon the additive finish on the threads involved and the smoothness of the thread surfaces. The torque values reported in this paper are the sum of these two forces plus the actual torque required to break the screw. The head friction and the thread friction are present in any loosening of the screw-nut combination and, obviously, the higher these friction values the less is the tendency of the screw fastening to loosen. Once the fastening has been made tight, any failure of the screw is usually due to the tension, shear, or fatigue stresses.

In the data published herein, a smooth hardened-steel block without additive finish such as plating, etc., was used under the head of the screw. The steel screws tested were all finished with a zinc plate (electrodeposited from a cyanide bath) of a minimum thickness of 0.0002 in. The brass screws employed had no additive finish. Since it is well known that some finishes will provide a much lower coefficient of friction than others, this fact should be given careful consideration in close design of screw fastenings.

The tension values reported were determined on an Amsler testing machine of 20,000 lb capacity using the 2000-lb scale, the tension being applied between the nut and the screw at a rate equivalent to a free head speed of 0.2 ipm until failure of the fastening occurred.

The impact values reported were determined by the use of a special fixture in a pendulum impact testing machine of 50 lb-ft capacity, shown in Figs. 2 and 3. The fixture used was

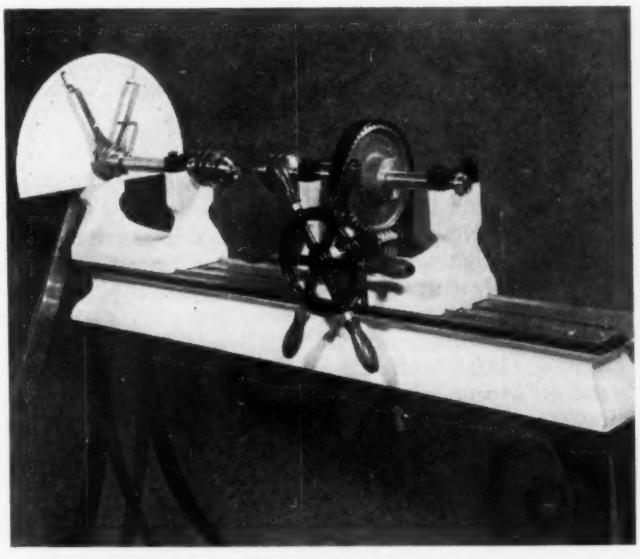

FIG. 1 TORSION-TEST MACHINE

[1] "Effect of Screw Threads on Fatigue," by S. M. Arnold, MECHANICAL ENGINEERING, July, 1943, pp. 497–505.

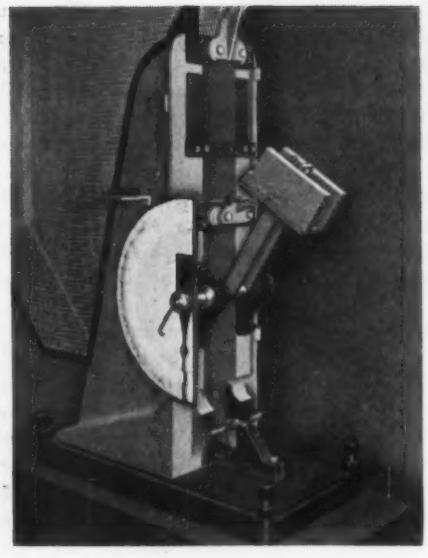

FIG. 2 IMPACT-TEST MACHINE

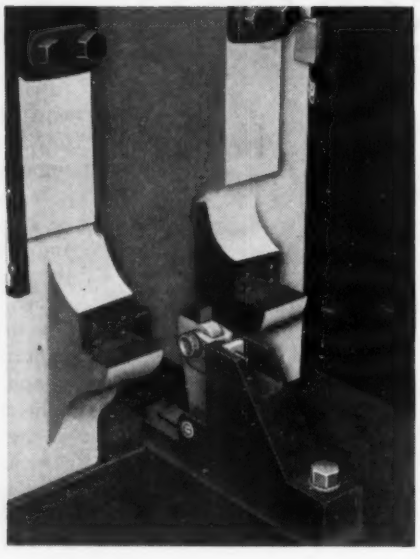

FIG. 3 CLOSE-UP OF SCREW-TEST FIXTURE

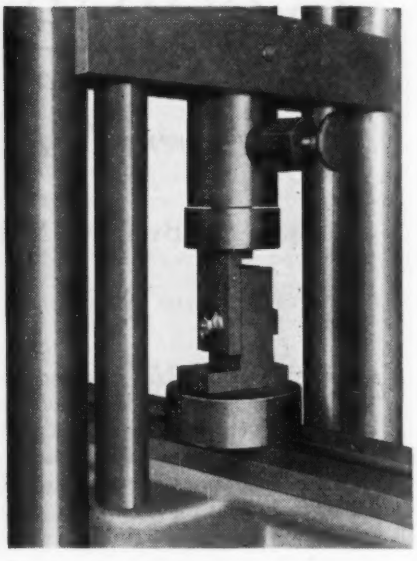

FIG. 4 SHEAR-TEST FIXTURE

calibrated and all impact values as read from the machine were corrected for the acceleration of the pivoted detail in the fixture.

The values of shear reported were obtained in a shear-test fixture on the Amsler 20,000-lb testing machine, using the 2000-lb scale. The fixture which consisted of two hardened-steel members held together with the screw under test is shown in Fig. 4. The pressure was applied to the assembly perpendicularly to the axis of the screw.

The metallic materials used for the tapped holes in the determination of these results were selected from those most commonly met in engineering design and are as follows:

1 The steel was low-carbon sheet comparable to S.A.E. Specification 1010–1015.

2 The brass was high-brass sheet, half hard, per A.S.T.M. Specification B-36, alloy 8.

3 The aluminum was alloy 17S-T strip.

4 The zinc-base die-casting material was in accordance with A.S.T.M. specification B-86, alloy 23.

In the case of nonmetallic materials N.E.M.A. standard grade XX laminated phenol fiber sheet was used, as well as some materials now in use as substitutes for this material, which are as follows:

1 Compressed boards made from exploded softwood fibers, commonly known as Tempered Presdwood (Masonite Corp.)

2 Compressed boards made from exploded hardwood fibers, commonly known as Tempered Die stock (Masonite Corp.)

3 Laminated lignin-plastic sheet.

USE OF DATA

Figs. 5 to 14, inclusive, are charts which may be used in several ways; for instance, in a particular design, due to space limitations, a No. 4 screw may be required to mount a piece of equipment weighing $^1/_4$ lb on a zinc-base die-cast part. The entire assembly must stand a shock of 10 g parallel to the axis of the screw. Reference to Fig. 9 shows that a No. 4 steel screw under tension will support about 500 lb with a $^1/_8$-in. thread engagement. Also, under shock conditions, these screws will stand an impact tension load of about 3 lb-ft. The determination of 10 g equals the weight of the part times 10; in this case $= ^1/_4 \times 10 = 2.5$ lb-ft, which is below the shock load that No. 4 screw will stand. Such a fastening would probably be satisfactory.

In another application, it may be advisable to know how much torque for a given thread engagement a No. 6 screw will stand before stripping, when engaged perpendicularly to the direction of manufacturing pressure in laminated phenolic sheet; reference to Fig. 10 will give this information.

In using these charts, it should be remembered that the values given are the average of at least five determinations. Because of this fact, an ample safety factor should be used in establishing loads or length of thread engagements in designs. It is evident from the charts that, in the weaker materials, longer thread engagements are required to develop the maximum strength of screw.

No figures have been given for tapped holes perpendicular to the direction of manufacturing pressure in laminated insulating materials. Several tests have been made on screws operating under these conditions, and it has been found that drilling and tapping is quite possible. The screws may be inserted, using light torques for clamping, without difficulty. However, when the torque is increased, the laminations often separate, causing the laminated sheet to split.

CONCLUSIONS

An examination of the data discloses the interesting fact that there is very little difference between lengths of the thread engagement required to develop the full strength of the screw when steel screws are used in tapped holes in steel, or in tapped holes in brass.

The full strength of brass screws when used in tapped holes in brass is developed in thinner stock than is required to develop the full strength of steel screws. The brass screws are, of course, of appreciably lower strength than the steel screws.

The data on steel screws in 17ST aluminum holes emphasizes the necessity for providing an adequate number of threads in engagement. The full strength of a steel machine screw is rarely developed in this aluminum alloy at thread engagements less than $^3/_{16}$ in. in length.

The zinc-base die-casting alloy, tested and reported upon, shows appreciably higher fastening strengths in thinner stock than the aluminum alloy.

Comparing phenolic sheet, lignin fiber, and the two types of compressed-wood fiberboards, the phenolic sheet develops the full strength of machine screws at appreciably lower thicknesses than the other materials. Unfortunately, adequate thicknesses of compressed boards of softwood fibers were not available to develop the full breaking strength of the machine-screw sizes tested, but based upon the corresponding data for pressed board of hardwood fibers, it appears that thread engagements of more than $^1/_2$ in. would be required. The strength of screw fastenings in lignin fiber is good, and of only slightly less magnitude than in phenolic sheet.

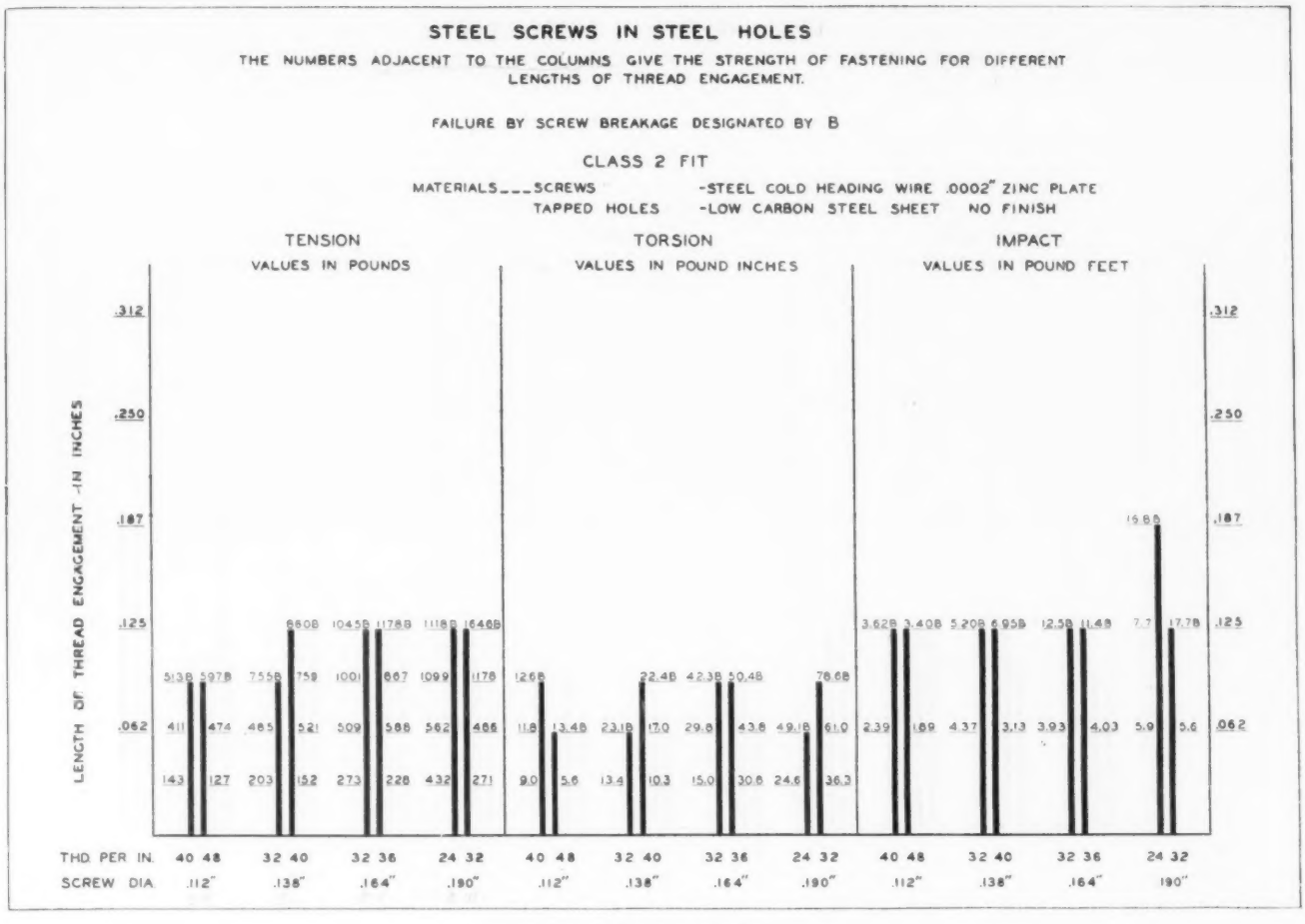
STEEL SCREWS IN STEEL HOLES
THE NUMBERS ADJACENT TO THE COLUMNS GIVE THE STRENGTH OF FASTENING FOR DIFFERENT LENGTHS OF THREAD ENGAGEMENT.
FAILURE BY SCREW BREAKAGE DESIGNATED BY B
CLASS 2 FIT
MATERIALS___SCREWS -STEEL COLD HEADING WIRE .0002" ZINC PLATE
TAPPED HOLES -LOW CARBON STEEL SHEET NO FINISH
TENSION
VALUES IN POUNDS
TORSION
VALUES IN POUND INCHES
IMPACT
VALUES IN POUND FEET
LENGTH OF THREAD ENGAGEMENT -IN INCHES
.312
.250
.187
.125
.062
THD. PER IN. 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32
SCREW DIA. .112" .138" .164" .190" .112" .138" .164" .190" .112" .138" .164" 190"

FIG. 5 STEEL SCREWS IN STEEL HOLES

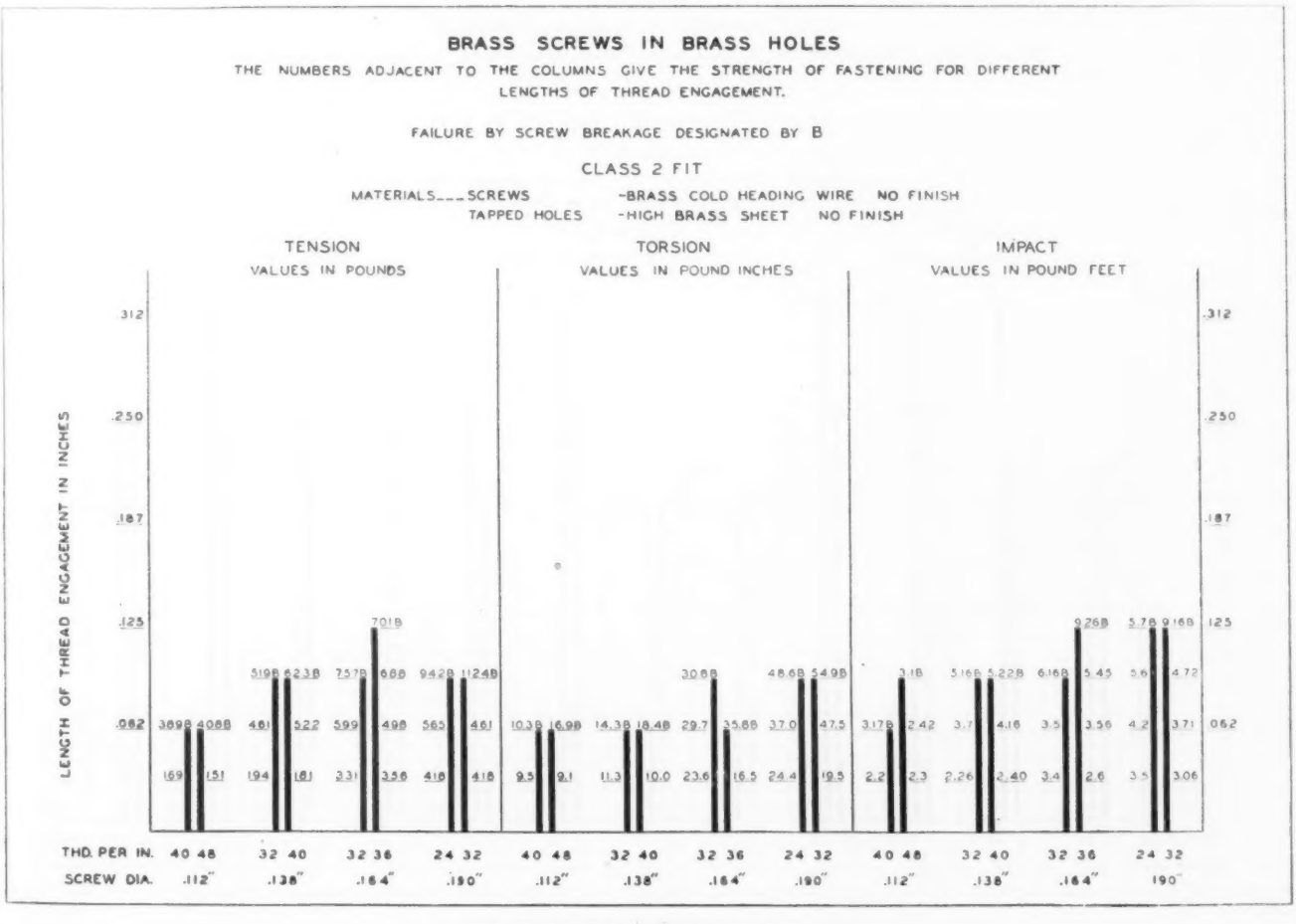
BRASS SCREWS IN BRASS HOLES
THE NUMBERS ADJACENT TO THE COLUMNS GIVE THE STRENGTH OF FASTENING FOR DIFFERENT LENGTHS OF THREAD ENGAGEMENT.
FAILURE BY SCREW BREAKAGE DESIGNATED BY B
CLASS 2 FIT
MATERIALS___SCREWS -BRASS COLD HEADING WIRE NO FINISH
TAPPED HOLES -HIGH BRASS SHEET NO FINISH
TENSION
VALUES IN POUNDS
TORSION
VALUES IN POUND INCHES
IMPACT
VALUES IN POUND FEET
LENGTH OF THREAD ENGAGEMENT IN INCHES
.312
.250
.187
.125
.062
THD. PER IN. 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32
SCREW DIA. .112" .138" .164" .190" .112" .138" .164" .190" .112" .138" .164" 190"

FIG. 6 BRASS SCREWS IN BRASS HOLES

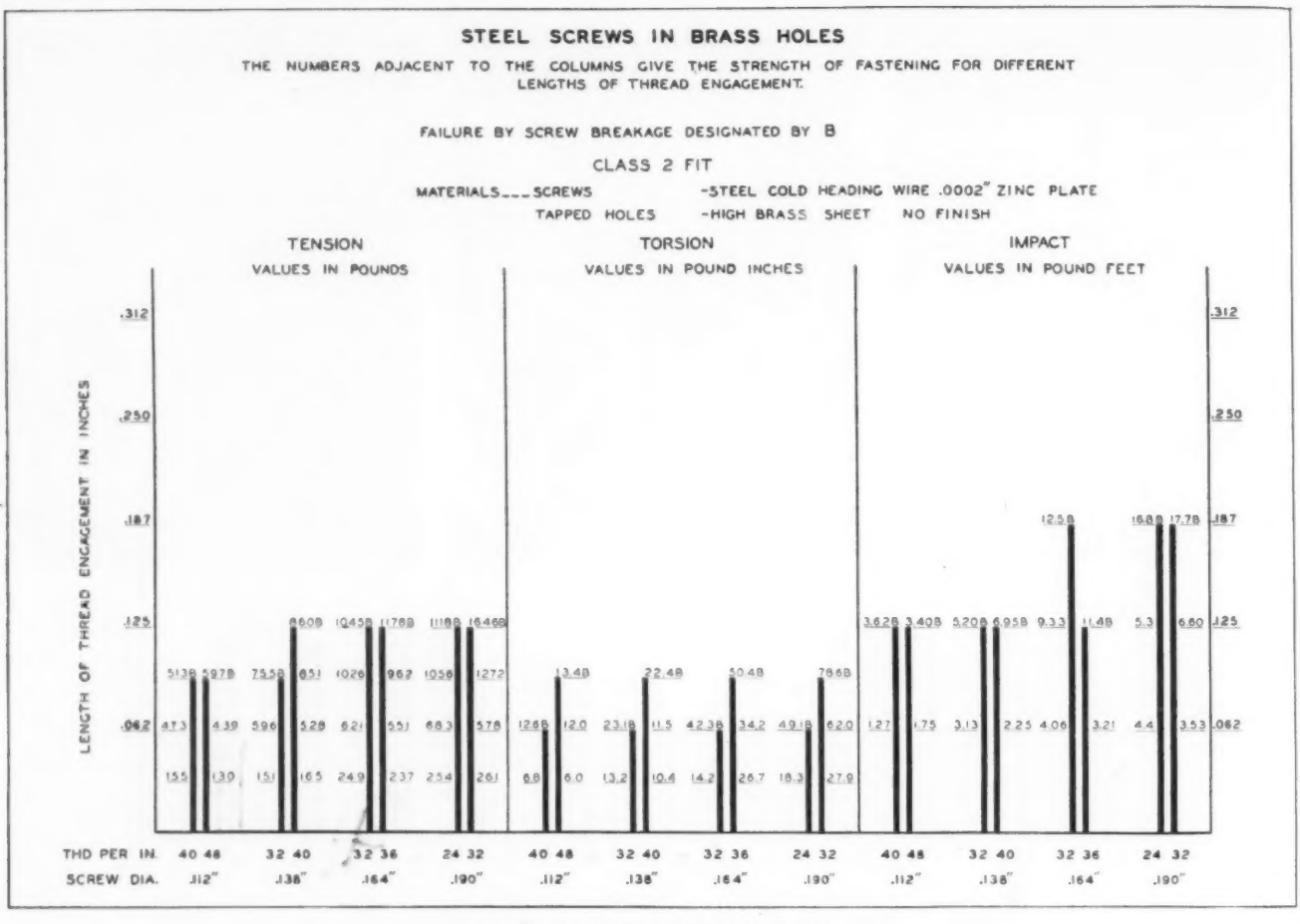
STEEL SCREWS IN BRASS HOLES
THE NUMBERS ADJACENT TO THE COLUMNS GIVE THE STRENGTH OF FASTENING FOR DIFFERENT LENGTHS OF THREAD ENGAGEMENT.
FAILURE BY SCREW BREAKAGE DESIGNATED BY B
CLASS 2 FIT
MATERIALS---SCREWS -STEEL COLD HEADING WIRE .0002" ZINC PLATE
TAPPED HOLES -HIGH BRASS SHEET NO FINISH
TENSION
VALUES IN POUNDS
TORSION
VALUES IN POUND INCHES
IMPACT
VALUES IN POUND FEET
LENGTH OF THREAD ENGAGEMENT IN INCHES
.312
.250
.187
.125
.062
THD PER IN. 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32
SCREW DIA. .112" .138" .164" .190" .112" .138" .164" .190" .112" .138" .164" .190"

FIG. 7 STEEL SCREWS IN BRASS HOLES

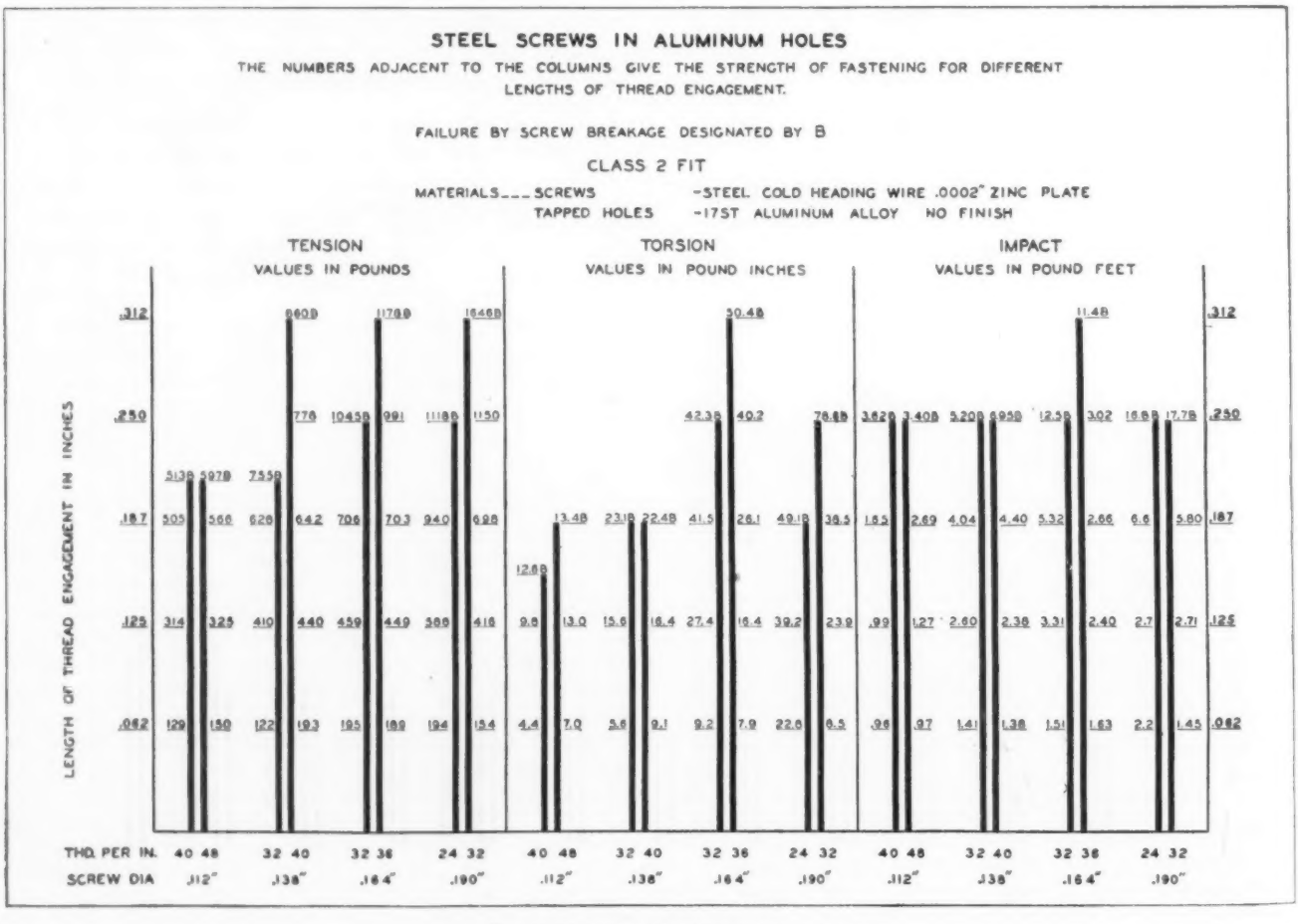
STEEL SCREWS IN ALUMINUM HOLES
THE NUMBERS ADJACENT TO THE COLUMNS GIVE THE STRENGTH OF FASTENING FOR DIFFERENT LENGTHS OF THREAD ENGAGEMENT.
FAILURE BY SCREW BREAKAGE DESIGNATED BY B
CLASS 2 FIT
MATERIALS---SCREWS -STEEL COLD HEADING WIRE .0002" ZINC PLATE
TAPPED HOLES -17ST ALUMINUM ALLOY NO FINISH
TENSION
VALUES IN POUNDS
TORSION
VALUES IN POUND INCHES
IMPACT
VALUES IN POUND FEET
LENGTH OF THREAD ENGAGEMENT IN INCHES
.312
.250
.187
.125
.062
THD. PER IN. 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32
SCREW DIA .112" .138" .164" .190" .112" .138" .164" .190" .112" .138" .164" .190"

FIG. 8 STEEL SCREWS IN ALUMINUM HOLES

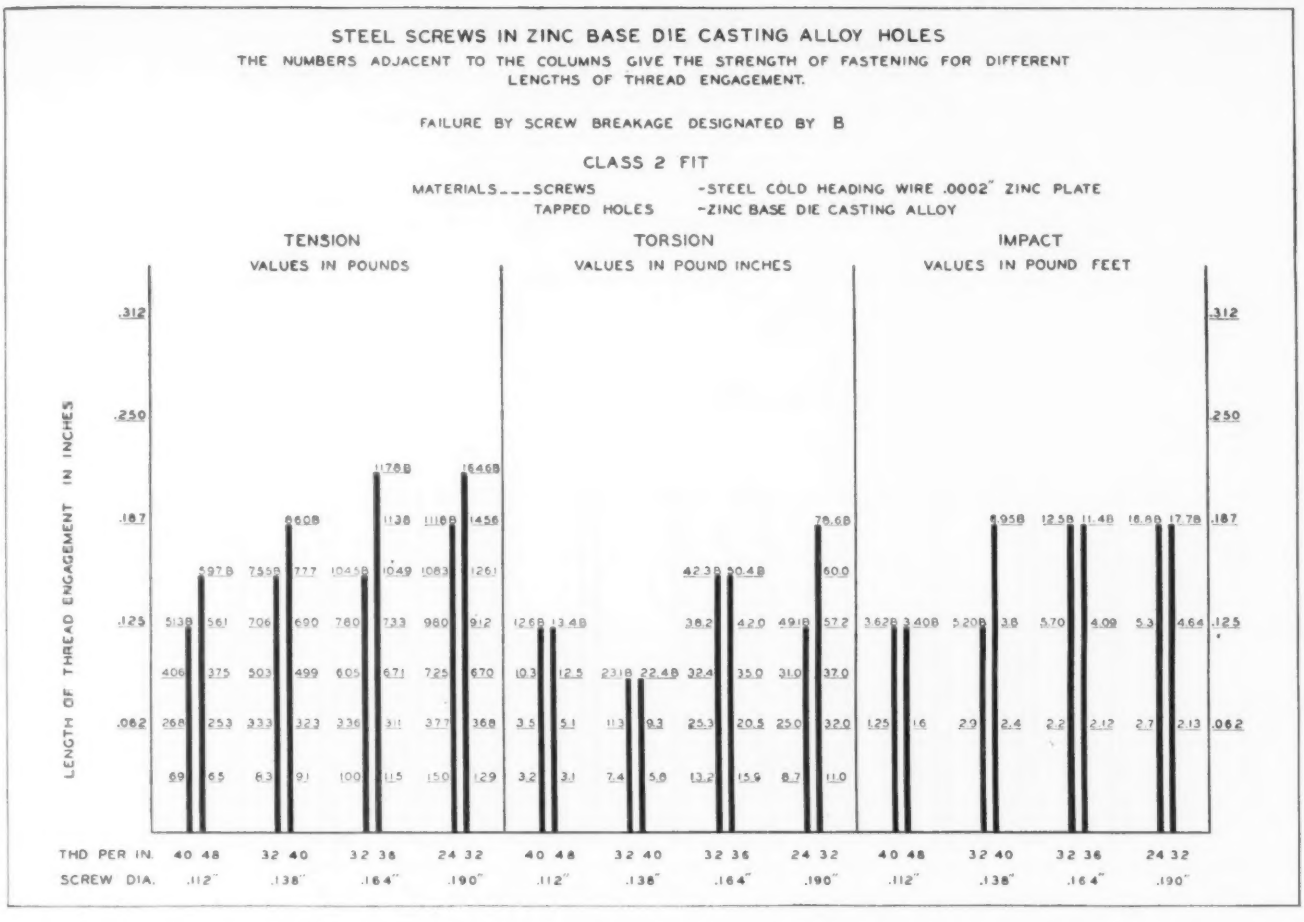
STEEL SCREWS IN ZINC BASE DIE CASTING ALLOY HOLES
THE NUMBERS ADJACENT TO THE COLUMNS GIVE THE STRENGTH OF FASTENING FOR DIFFERENT LENGTHS OF THREAD ENGAGEMENT.
FAILURE BY SCREW BREAKAGE DESIGNATED BY B
CLASS 2 FIT
MATERIALS---SCREWS -STEEL COLD HEADING WIRE .0002" ZINC PLATE
TAPPED HOLES -ZINC BASE DIE CASTING ALLOY
TENSION
VALUES IN POUNDS
TORSION
VALUES IN POUND INCHES
IMPACT
VALUES IN POUND FEET
LENGTH OF THREAD ENGAGEMENT IN INCHES
.312
.250
.187
.125
.062
THD PER IN. 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32
SCREW DIA. .112" .138" .164" .190" .112" .138" .164" .190" .112" .138" .164" .190"

FIG. 9 STEEL SCREWS IN TAPPED HOLES IN ZINC-BASE DIE-CASTING MATERIAL PER A.S.T.M. B-86 ALLOY XXIII

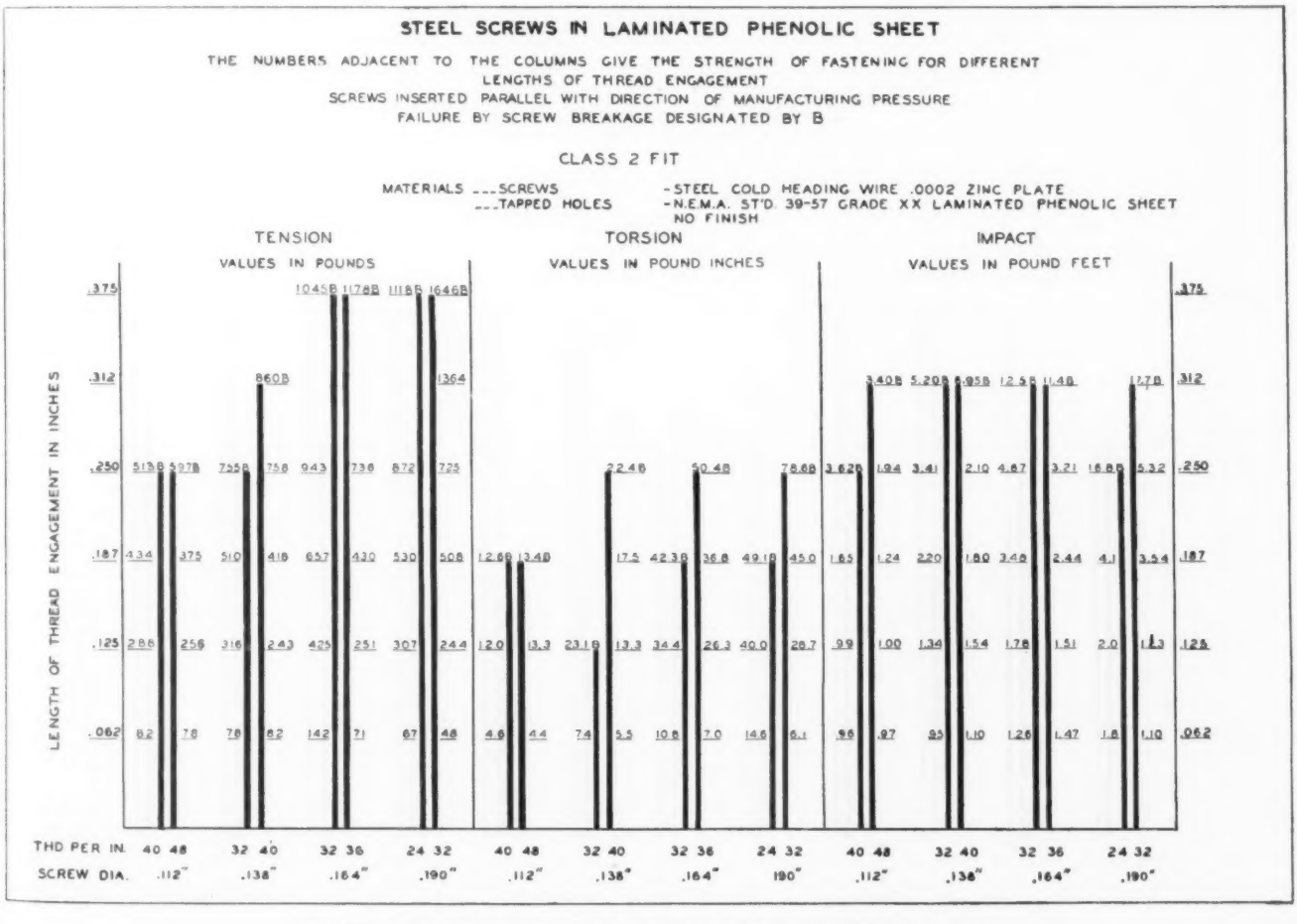
STEEL SCREWS IN LAMINATED PHENOLIC SHEET
THE NUMBERS ADJACENT TO THE COLUMNS GIVE THE STRENGTH OF FASTENING FOR DIFFERENT LENGTHS OF THREAD ENGAGEMENT
SCREWS INSERTED PARALLEL WITH DIRECTION OF MANUFACTURING PRESSURE
FAILURE BY SCREW BREAKAGE DESIGNATED BY B
CLASS 2 FIT
MATERIALS ---SCREWS -STEEL COLD HEADING WIRE .0002 ZINC PLATE
---TAPPED HOLES -N.E.M.A. ST'D. 39-57 GRADE XX LAMINATED PHENOLIC SHEET NO FINISH
TENSION
VALUES IN POUNDS
TORSION
VALUES IN POUND INCHES
IMPACT
VALUES IN POUND FEET
LENGTH OF THREAD ENGAGEMENT IN INCHES
.375
.312
.250
.187
.125
.062
THD PER IN. 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32
SCREW DIA. .112" .138" .164" .190" .112" .138" .164" .190" .112" .138" .164" .190"

FIG. 10 STEEL SCREWS IN TAPPED HOLES IN LAMINATED PHENOLIC SHEET

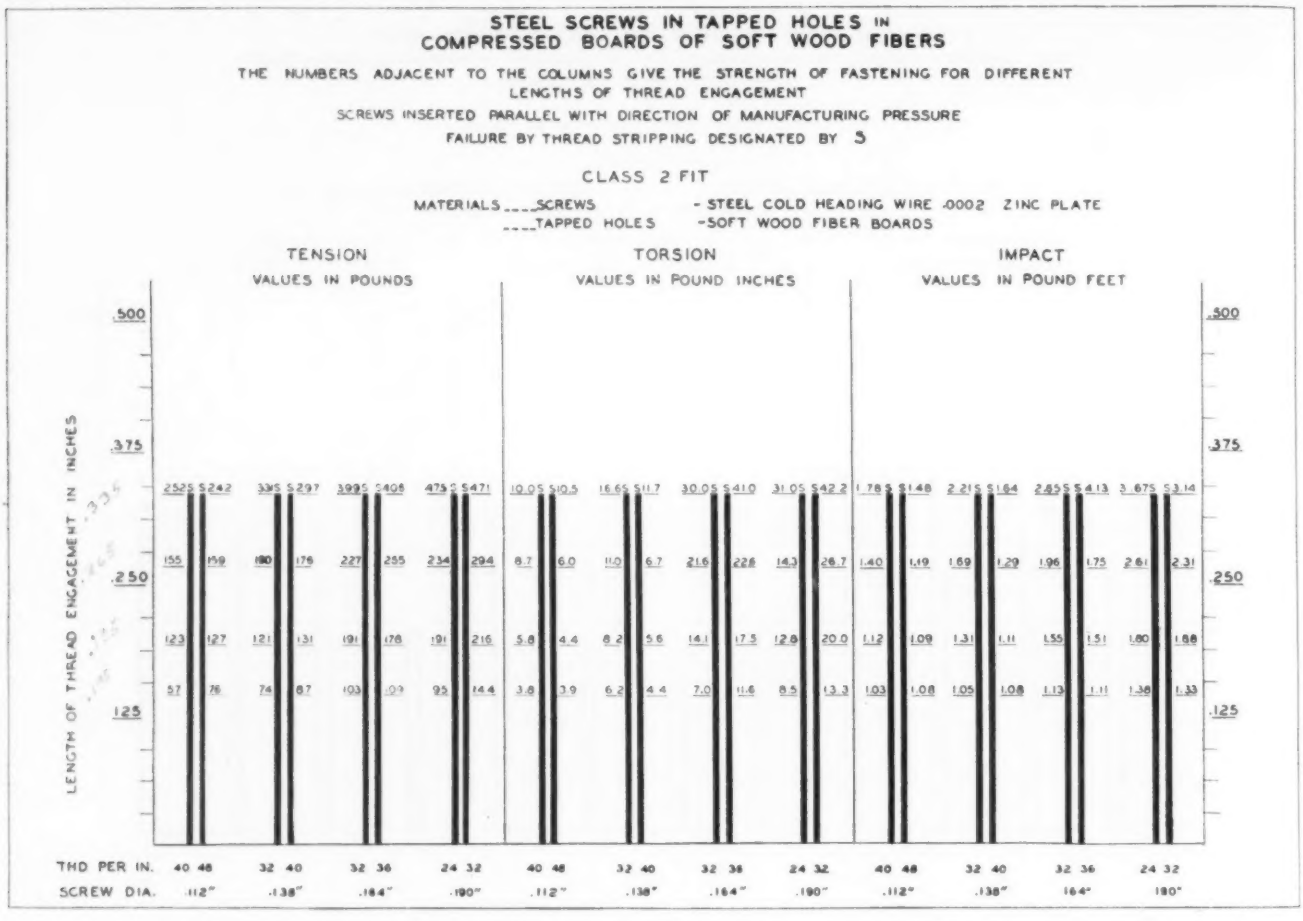
STEEL SCREWS IN TAPPED HOLES IN
COMPRESSED BOARDS OF SOFT WOOD FIBERS
THE NUMBERS ADJACENT TO THE COLUMNS GIVE THE STRENGTH OF FASTENING FOR DIFFERENT LENGTHS OF THREAD ENGAGEMENT
SCREWS INSERTED PARALLEL WITH DIRECTION OF MANUFACTURING PRESSURE
FAILURE BY THREAD STRIPPING DESIGNATED BY S
CLASS 2 FIT
MATERIALS ___SCREWS - STEEL COLD HEADING WIRE .0002 ZINC PLATE
____TAPPED HOLES -SOFT WOOD FIBER BOARDS
TENSION
VALUES IN POUNDS
TORSION
VALUES IN POUND INCHES
IMPACT
VALUES IN POUND FEET
LENGTH OF THREAD ENGAGEMENT IN INCHES
.500
.375
.250
.125
THD PER IN. 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32
SCREW DIA. .112" .138" .164" .190" .112" .138" .164" .190" .112" .138" 164" 190"

FIG. 11 STEEL SCREWS IN TAPPED HOLES IN COMPRESSED BOARDS MADE FROM EXPLODED SOFTWOOD FIBERS

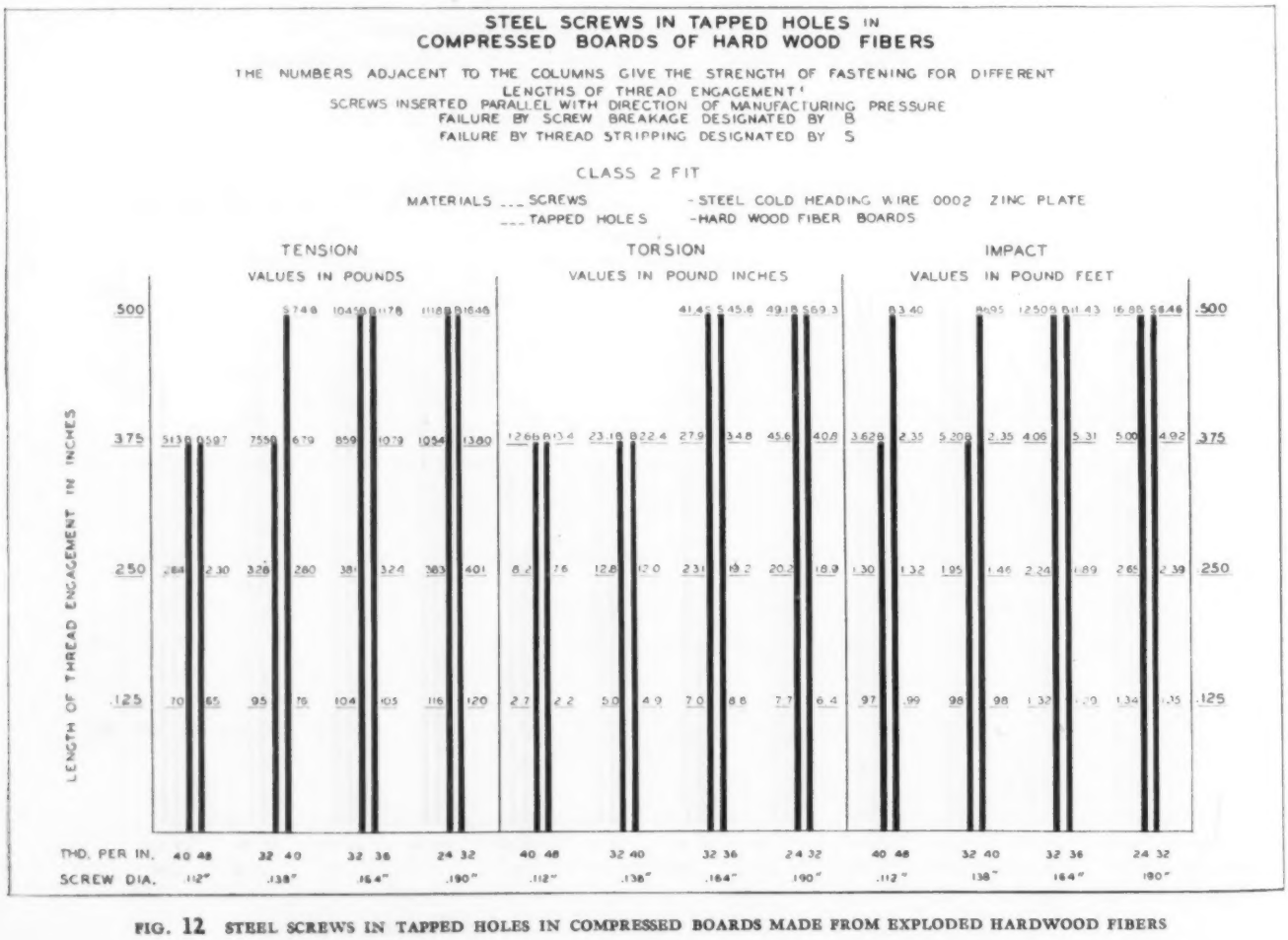
STEEL SCREWS IN TAPPED HOLES IN
COMPRESSED BOARDS OF HARD WOOD FIBERS
THE NUMBERS ADJACENT TO THE COLUMNS GIVE THE STRENGTH OF FASTENING FOR DIFFERENT LENGTHS OF THREAD ENGAGEMENT
SCREWS INSERTED PARALLEL WITH DIRECTION OF MANUFACTURING PRESSURE
FAILURE BY SCREW BREAKAGE DESIGNATED BY B
FAILURE BY THREAD STRIPPING DESIGNATED BY S
CLASS 2 FIT
MATERIALS ___SCREWS - STEEL COLD HEADING WIRE .0002 ZINC PLATE
____TAPPED HOLES -HARD WOOD FIBER BOARDS
TENSION
VALUES IN POUNDS
TORSION
VALUES IN POUND INCHES
IMPACT
VALUES IN POUND FEET
LENGTH OF THREAD ENGAGEMENT IN INCHES
.500
.375
.250
.125
THD. PER IN. 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32
SCREW DIA. .112" .138" .164" .190" .112" .138" .164" .190" .112" 138" 164" 190"

FIG. 12 STEEL SCREWS IN TAPPED HOLES IN COMPRESSED BOARDS MADE FROM EXPLODED HARDWOOD FIBERS

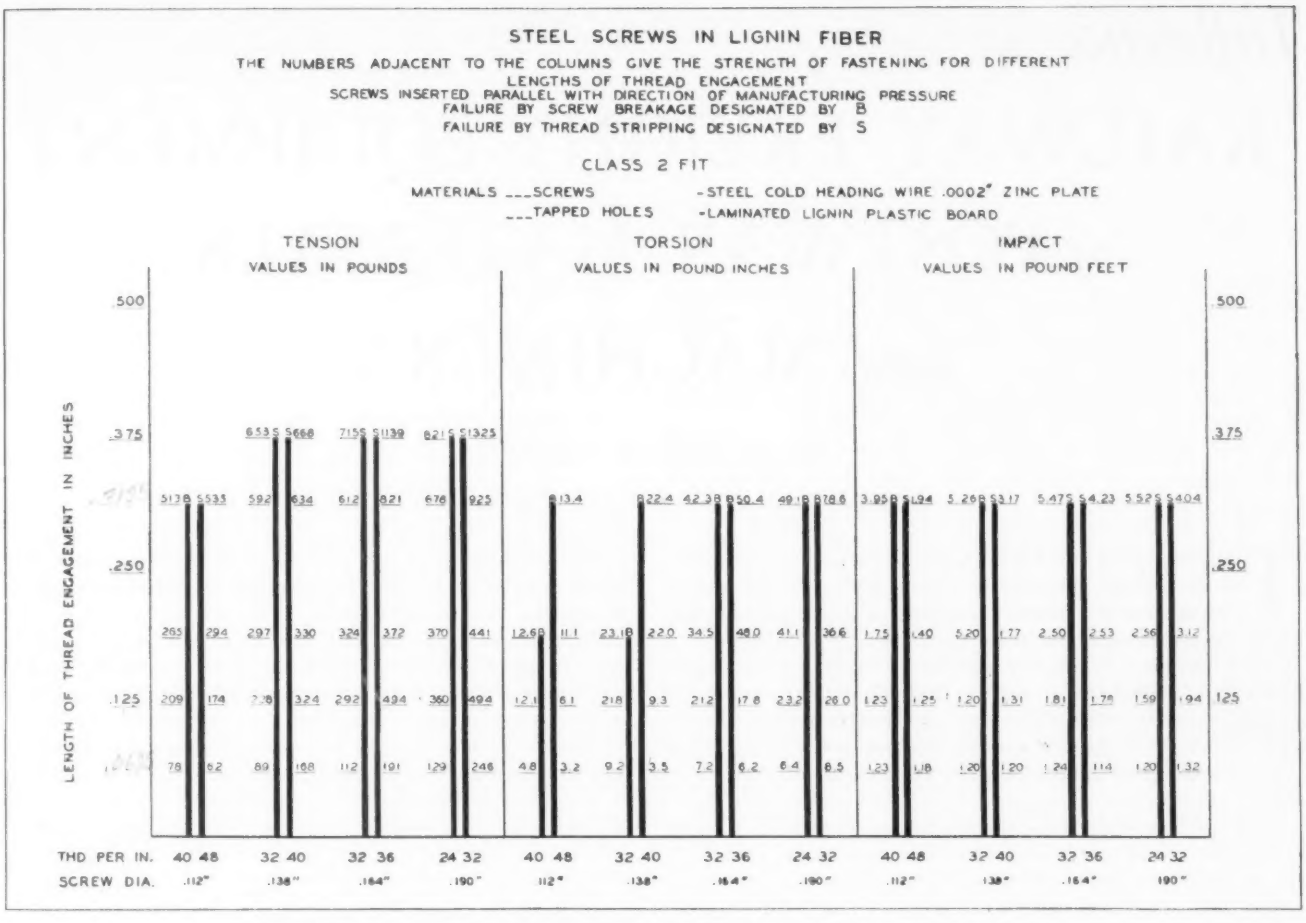
STEEL SCREWS IN LIGNIN FIBER
THE NUMBERS ADJACENT TO THE COLUMNS GIVE THE STRENGTH OF FASTENING FOR DIFFERENT LENGTHS OF THREAD ENGAGEMENT
SCREWS INSERTED PARALLEL WITH DIRECTION OF MANUFACTURING PRESSURE
FAILURE BY SCREW BREAKAGE DESIGNATED BY B
FAILURE BY THREAD STRIPPING DESIGNATED BY S
CLASS 2 FIT
MATERIALS ___SCREWS -STEEL COLD HEADING WIRE .0002" ZINC PLATE
___TAPPED HOLES -LAMINATED LIGNIN PLASTIC BOARD
TENSION
VALUES IN POUNDS
TORSION
VALUES IN POUND INCHES
IMPACT
VALUES IN POUND FEET
LENGTH OF THREAD ENGAGEMENT IN INCHES
.500
.375
.250
.125
THD PER IN. 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32 40 48 32 40 32 36 24 32
SCREW DIA. .112" .138" .164" .190" 112" .138" .164" .190" .112" .138" .164" .190"

FIG. 13 STEEL SCREWS IN TAPPED HOLES IN LAMINATED LIGNIN PLASTIC BOARD

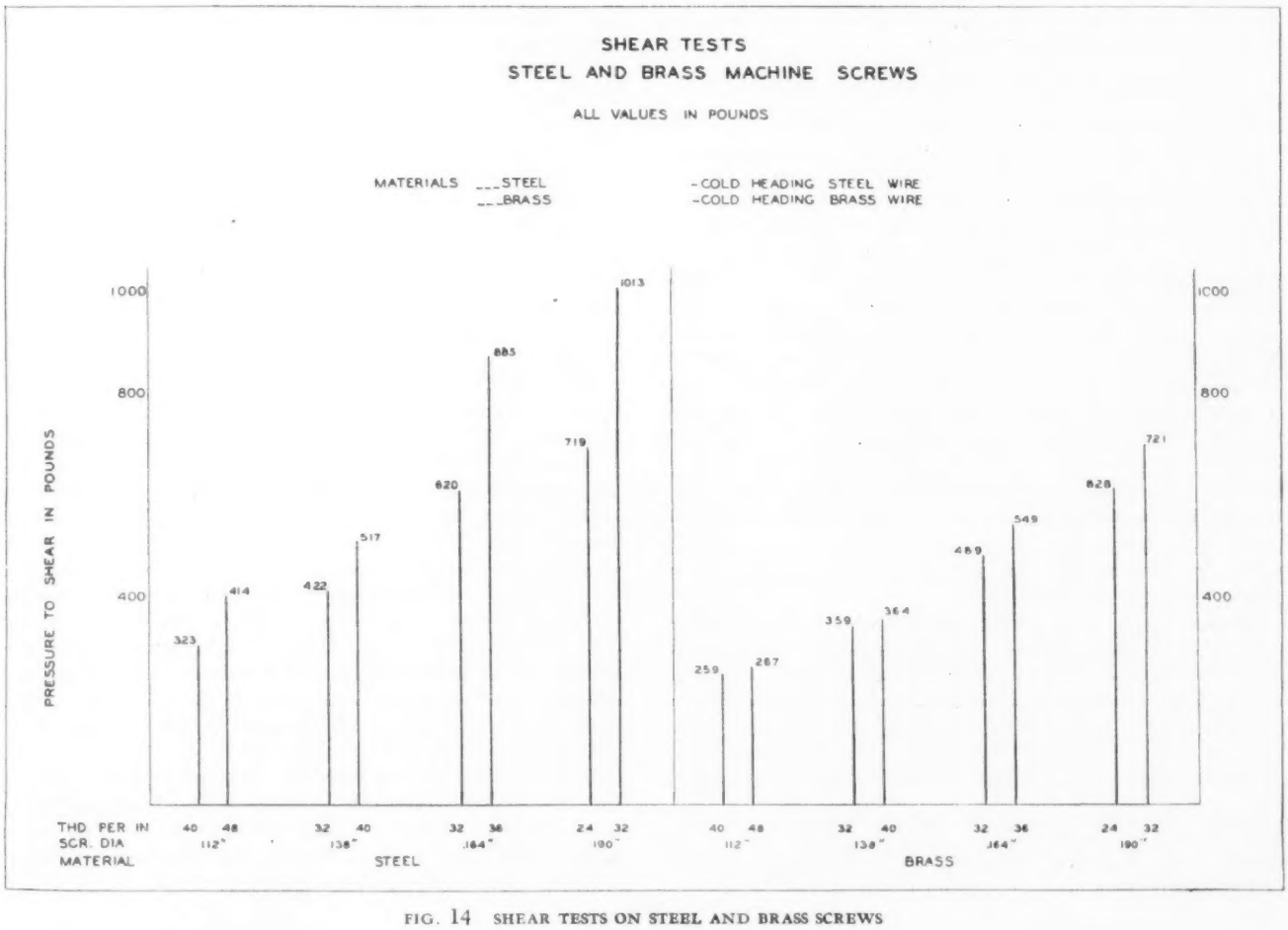

FIG. 14 SHEAR TESTS ON STEEL AND BRASS SCREWS

Influence on RAILWAY FREIGHT EQUIPMENT *of* POSTWAR MATERIALS *and* MACHINERY

By MORRIS P. TAYLOR

ASSISTANT MECHANICAL ENGINEER, SOUTHERN PACIFIC COMPANY, SAN FRANCISCO, CALIF.

THE haulage of heavy basic commodities, such as products of agriculture, mines, and forests, for long distances at low rates is the primary function of American railways and in normal times accounts for the great bulk of railway traffic and income. When the general postwar transportation situation is considered, it is plain that this type of traffic will account for an increasingly large proportion of railway income, as railways are in the best competitive position to handle this type of haulage as compared with other forms of transportation.

Rail haulage will remain predominant especially if rate-making bodies take a realistic view of transportation and allow the railroads to quote the lowest rates they can profitably work under, with reductions for quantity shipments and for backhaul, irrespective of whether other means of transportation can operate at such rates. Our economic system can function only if the lowest-cost producer is allowed to reduce prices as far as he is able at a profit.

RAILROADS OFFER LOW-COST RELIABLE SERVICE

The requirements for transportation of heavy bulk commodities are low cost and reliability of service; speed is secondary, to the extent that lower rates will in most cases attract traffic to slower routes. The primary advantage of rail transportation for heavy haulage lies in the very low coefficient of friction of railway freight equipment, which varies from 0.002 to 0.004 for total over-all resistance at normal freight-operating speeds. With this extremely low traction resistance, a freight train can make entirely satisfactory schedules in average territory for heavy-commodity haulage with less than 2 hp per net ton of load; and the energy requirements are in the neighborhood of 0.03 hp-hr per ton-mile. In level territory, and where heavy coal and ore shipments are handled, the foregoing requirements are greatly reduced and may even be below 1 hp per net ton. In mountainous territory, of course, the power requirements increase; but due to the locomotive power being independent of the train, helpers can be cut in and out as required, so this does not greatly increase the over-all power requirements on long hauls.

Because of the low power requirements and inherent efficiency of rail haulage, this mode of transport will continue to dominate the field of heavy transportation over long distances; and with the potential postwar increase in the standard of living, the shipments of bulk commodities will increase. There are, therefore, no grounds for assuming that the railways are a declining industry, particularly in view of the splendid technical job they have done in handling the extreme war-emergency traffic with little increase in either facilities or personnel.

However, in spite of the present efficiency of rail haulage, in the postwar period there will be available new materials, new machinery, and new devices, which will further increase the efficiency of rail haulage. At the same time there may be distinct shifts in the railway-fuel situation that may have far-reaching effects on the types of power used. It is the purpose of this paper to examine these potentialities in a general way and to point out possible trends and developments without making arbitrary predictions; to promote speculative technical thinking, not to tell what is going to happen.

SOURCES OF POWER

Fuel to produce power, or power itself, is one of the principal commodities used by a railway for freight haulage. The sources of railway power used in this country are three, i.e., coal, products of petroleum, and electricity. Coal is the principal fuel used on American railways. Throughout most of the country there are ample deposits that can be worked at reasonable cost, and there are known to be vast reserves, not only of bituminous coal but of low-grade lignites, that can be and are being utilized for railway power. Coal, although by all odds the cheapest fuel per heat unit in most parts of the United States, is more expensive to handle than oil and is utilized at a much lower thermal efficiency than petroleum fuels. However, in areas where low-cost coal is available on the line, it will, in many cases, give the lowest fuel cost per ton-mile hauled.

The petroleum situation is much less clear; in fact it is so confused the industry itself does not agree as to the postwar position. Predictions as to the future petroleum supply have always been, from their very nature, extremely difficult, and many first-class geologists have made forecasts that have been entirely disproved by later developments. Nevertheless, it seems probable that this country, in the postwar era, will not be in the surplus position that it was in prewar times. The United States has undoubtedly vast resources of petroleum, but some of these resources may be available only at higher costs. There will be vast demands for petroleum products. In spite of the probable improved gasoline mileage of postwar automobiles, industry and living may be spread out over wider areas, resulting in greatly augmented annual mileage, which will be further increased by higher standards of living. Therefore, it is entirely possible that the United States after the war may be the world's greatest producer of petroleum, and at the same time a net importer. Any shift from the prewar surplus position will raise the price levels of petroleum products and will also intensify the cracking process.

Contributed jointly by the Pacific Railway Club and the A.S.M.E. Railroad Division and presented at the Semi-Annual Meeting, Los Angeles, Calif., June 14–17, 1943, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Railways use two kinds of petroleum fuels, low-grade oils, usually cracking-still residues, and Diesel fuel, a distilled product having a refinery cost little below gasoline. If the gasoline demand should be such as to put this country in a net importing position, cracking and other conversion processes will be further stepped up, and there will be a reduction in the supply of Diesel and residual-fuel fractions, which may affect the operation of railroads that do not have cheap coal available. Of course, all predictions on petroleum supply are hazardous, but it is doubtful if we will return to the prewar position of Government curtailment to prevent oversupply.

Electric power in the postwar era will be obtainable in large blocks at very low rates, especially in some parts of the West and South, and will probably be used more extensively for main-line freight haulage, especially if certain other material possibilities develop.

POSSIBLE TRENDS IN FREIGHT-LOCOMOTIVE DESIGN

The fuel situation is of course directly related to the types of locomotives available to utilize the various sources of power, so it is next necessary to examine the effect of postwar developments on freight locomotives. The present locomotives available for freight haulage are direct-connected steam, Diesel-electric, and electric. To these there will be added in the postwar era the combustion turbine and the steam turbine, both with electric drive. A possible variant is the mercury-steam turbine, using electric drive.

Steam Locomotive. The present type of steam locomotive will be further improved in power, reliability, and low maintenance cost in the postwar period. When the X-ray apparatus now being used for war products becomes generally available, the welded locomotive boiler will be used entirely, provided of course the present Government restrictions on welded boilers are removed. Welding will reduce the weight of boilers, and practically eliminate pitting and caustic embrittlement. The machinery and running gear will be materially reduced in weight by the war developments in low-cost alloy steels. Poppet valves, which are successfully used at present, will be widely applied after the war and promise a 20 per cent saving in fuel, or better. The use of light alloys for the nonstructural parts of the locomotive and tender will eliminate a great deal of parasitic weight, and aluminum or alloy reciprocating parts will practically eliminate dynamic overbalance on the rail. However, in spite of all improvements, the direct-connected steam locomotive will never have a high thermal efficiency, due to the narrow temperature limits within which it operates. It will, however, be used where cheap coal or by-product oil is available; and also in other services where the hours operated per year are limited by traffic requirements, so that its low carrying charges will more than compensate for its higher operating costs.

Diesel-Electric Locomotive. The Diesel-electric locomotive has many advantages for freight service as it is powerful, smooth, and efficient, and its use will expand especially on heavy grades and in territories where water for locomotive boilers is scarce and poor. The great advantage of the Diesel up to the present lies in the availability of its full horsepower over a wide range of speeds, which on heavy grades results in greater trainloads per locomotive unit. In certain territories the Diesel has lower power-plant operating costs, but this may not be true in cheap-coal districts. The principal disadvantage of the Diesel lies in the high first cost, which makes it less suitable for seasonal traffic.

The postwar changes in the Diesel will be toward the use of smaller, higher-speed engines to reduce first cost, maintenance, and oil consumption; and in reducing weight, both by the use of light metals and higher-speed engines. The present units are about 25 per cent overweight as compared with the ideal, and the excess will be eliminated in postwar designs. The lower weight will also reduce the initial cost, which will further the use of Diesels for main-line freight transportation. In a way, however, the Diesel may be handicapped in the postwar era by the general petroleum situation, as intensified demands for higher-grade fuels may result in cracking the Diesel-oil fractions.

Electrification of Main Lines. There is a decided possibility of main-line railway electrification in the postwar era, especially on western lines. Given cheap metals for transmission lines, cheap electrical power available in large blocks, a low rate of interest to encourage postwar employment, together with vacuum-tube converters and other refinements, the electrification of western mountain grades is not an impossibility, especially if we are to be in a net importing position in regard to petroleum. The characteristics of the electric locomotive are well known; it can be built to any power and to practically any desired power characteristic; it is at present the lightest form of locomotive, so much so it often has to be ballasted to get sufficient adhesion. In this connection, it should be pointed out that the development of the Diesel has in a way advanced the possibility of main-line electrification, as Diesel-electric switching and local freight units can be used, taking overhead power on main line and using the Diesel engine in yards and on industrial tracks. This eliminates the necessity for a lot of expensive overhead wiring over little-used trackage. From the standpoint of long-range national planning, the electrification of heavy grades has everything to commend it, as the use of hydropower will conserve fuel resources for other essential uses.

Combustion-Turbine Locomotive. The combustion-turbine locomotive with electric transmission was being developed just before the war and will undoubtedly come on the market after the war. Its advantages would be the low maintenance and light weight of the turbine, the ability to burn residual oils, and a fuel efficiency more than double that of the steam locomotive. Its first cost should be somewhat below the Diesel, and its fuel cost not much above, owing to the lower cost of bunker oil as compared to Diesel fuel. The steam turbine with electric drive was tried experimentally before the war, but was handicapped by the difficulties of condensing large amounts of steam and obtaining a good vacuum with an air-cooled condenser.

The Mercury Cycle. A possible variant of the turbine is to use the binary cycle, a mercury cycle over the steam cycle, which would have great advantages for locomotive use. Due to the higher upper temperature limit of the mercury cycle, it would be possible to get a thermal efficiency of about 20 per cent with a condenser temperature of 280 F. This would give a 180-deg F drop across the condenser surfaces under all conditions, which would solve the condenser problem. A mercury-steam locomotive could burn pulverized coal, and with coal at $3 per ton the fuel cost would be far below that of any present form of self-contained locomotive. The binary cycle has great possibilities, and undoubtedly in the postwar period such freight locomotives will be developed and placed on the market.

FREIGHT CARS WILL UNDERGO RADICAL CHANGES

Freight cars in the postwar era will be much changed, with new materials and improved design, the objects being to reduce weight, improve high-speed riding qualities, and reduce maintenance. In all questions of freight-car construction, however, it must be remembered that a freight car is not only a carrying vehicle but also a storage warehouse, and that in many lines of traffic the demand for cars is highly seasonal. There is, therefore, a point beyond which it does not pay to go in using lightweight materials for freight-car construction, unless the cost per car can be kept down.

Car underframes will probably be made of welded low-alloy

steel, unless aluminum is so reduced in price as to be directly competitive on a strength basis. The present aluminum alloys have fatigue and elastic characteristics not entirely desirable for this type of work, but these may be overcome with improved technique. Car end castings, bolsters, etc. will be of cast or fabricated alloy steel, with possible use of light metals.

Open-top cars, for the bulk transportation of coal, ore, and crushed rock, will be made of corrosion- and abrasion-resisting alloy steels, of the medium-manganese type, of welded construction. In this class of service resistance to abrasion due to pouring in and dumping the load, and to shock and abuse, is of paramount importance, and so far none of the light metals possesses these characteristics. Tank cars will be made of welded alloy steel, of aluminum, or of magnesium. There seems no reason to expect the extremely efficient monocoque construction of the cars to be altered. Flexible bladder linings, of acid-resistant rubberlike compounds, will considerably simplify the problem of tank-car supply, as the same cars could be used for many commodities.

Flat cars will be made of alloy steel, welded, and will be made more extensively in the well construction, to facilitate the transportation of large prefabricated units within the present clearance limits. It is possible, of course, that light alloys will be used for flat cars, but the problem will be one of weight-saving as compared to price, provided the light alloys will stand up to the service.

House cars, such as box, auto, furniture, and refrigerated cars, probably will be changed more due to postwar materials than will the classes of cars previously mentioned. The upper or house part of the structure can be made of welded alloy steel, light metal, molded plywood, or of improved wood construction, using high-strength glues and timber connectors. There are advantages in each of these materials, and it is difficult to make any definite selection at the present time. However, both the molded plywood and wood constructions have some definite advantages that make it probable they will be widely used. A metal boxcar must have a wood or plastic lining, both for insulation and for nailing dunnage to secure loads, and it seems logical to use such material structurally as part of the panel. Molded plywood is especially suitable in the design of a wagon-top type of car, by using one panel from frame to frame, with no independent roof structure. Inside the outer panel would be a glued frame structure and insulation, with an inner skin of plywood or wood.

Wood, chemically treated to prevent decay and checking, has also great possibilities for house cars, especially with the perfection of waterproof high-strength glue. With such a glue, it would be possible to make a double-sheathed car, the sheathing set diagonally to cross, all glued together, which would make a very strong panel. Roof framing could be glued and double-diagonal planked or metal-sheathed. The connections to the metal underframe could be best handled by some sort of toothed or ring connectors.

WIDER USE OF CONTAINER SYSTEM

Container cars for the handling of less-than-carload freight have never been developed to their maximum potentialities, and the handling of less-carload freight has not been on the same efficient plane as has carload freight. The ideal container would be strong and light, and designed into a transfer system so that it could be readily shifted in a few minutes to or from a standard motor truck or trailer for terminal pickup and delivery. Such containers should be made to a national standard, and possibly should be so designed as to be usable on rail, truck, or air transport. With containers that are quickly transferable, it is entirely possible to image a local freight service stopping every 10 miles or so and making about the same speeds as a local passenger train at present, from 35 to 40 mph.

The containers themselves would be of light metal or plywood, the cars would be of alloy steel with special arrangements to secure the containers, and some sort of cheap automotive crane or rail arrangement used for the transfer. Such a system would solve many pickup and terminal problems, and would reduce the cost of small freight shipments nearer to the carload level.

Freight-car trucks will be greatly altered in the postwar period, continuing the development that was actively taking place before the war to improve high-speed riding qualities and to reduce weight, particularly unsprung weight. Truck frames will continue to be developed along these lines, with light alloy steels and light metals used for the structural parts, and with alloy-steel axles to reduce weight. For certain types of cars, the truck may be dispensed with, and the frame load carried on many axles supported by pedestals from the main frame, similar to the new General Steel Company's tender bed construction used on recent locomotive tenders on many lines.

BEARINGS FOR POSTWAR FREIGHT CARS

The question of bearings for postwar freight cars is an open one. The present standard oil-waste-packed journal bearing is quite efficient, having a coefficient of friction of less than 0.002 at normal running speeds. However, the bearing is lacking in reliability, and it is difficult to reduce hotboxes to below 1 per 1,000,000 car-miles. Continuous inspection is also required. On the other hand, the bearing is easily changed in a few minutes. The roller bearing, which is being widely advocated for freight equipment, has been used on passenger cars for many years, and its original trouble with broken axles has been overcome by intensive research. The roller bearing has the advantages of great reliability, low lubrication cost, and much lower starting friction. It has the disadvantages of high first cost and of being difficult to handle on the road in case of a bearing failure. It is debatable whether the friction at running freight-train speeds, up to 60 or 70 mph, is materially lower with roller bearings; and test results conflict.

Further to complicate the postwar bearing situation, several improved forms of oil-lubricated bearings, both of the capillary and of the disk-oiling type, have been developed, and improvements have been made in the standard bearing to eliminate waste grab, the principal cause of hot boxes. On the other hand, the roller bearing can undoubtedly be reduced in price if on a mass-production basis, and the competition will, therefore, undoubtedly be keen, with both types of bearings in use.

Springs, both for carrying and draft gear, will be improved greatly, with rubber and hydraulic damping used to reduce shocks under all conditions. Air brakes, which have been so improved in recent years that the speed of propagation through the train approaches the speed of sound, will continue to be improved. The next problem, which will be intensified by the lightweight car, is that of obtaining variable braking power for loads and empties; and the present empty and load brake, automatically actuated by spring height, will be widely used.

CONCLUSIONS

Summing up, the possibilities of lightweight freight cars in reducing transportation costs are immense. A reduction of, say, 3 tons per car would increase the pay load of the average freight train about 5 to 7 per cent and would reduce transportation and locomotive power costs in proportion, and additional savings in weight would result in further great savings. All in all, in spite of the development of other forms of transport, the rails will continue to haul the bulk of the nation's freight ton-miles; and such possible cost reductions give promise of large savings to producer and consumer, which should augment the postwar standard of living.

Salvaging AIRCRAFT STRUCTURES *in Process of Manufacture*

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THE question of salvaging airframes during the process of manufacture has been a matter of grave concern to all aircraft producers. Before Pearl Harbor, the question of quality was paramount and, frequently, damaged parts and assemblies were unhesitatingly scrapped. Today, with our nation at war, the question of serviceability has superseded that degree of quality which bespeaks of expert craftsmanship. This is obvious when it is remembered that far fewer skilled man-hours are expended in building aircraft today than in the previous era. The craftsman of those days is the foreman of today, while new and inexperienced workmen constitute the ranks of the modern aircraft worker. Thus, with emphasis being placed upon production, great responsibility rests on the small group of engineers and inspectors who in every plant must keep a constant vigil to maintain a high standard of quality and serviceability.

Despite all attempts to make aircraft design simple, present-day high-performance airplanes are still extremely complicated. Before any given design reaches the production stage, thousands of hours of thoughtful study, careful planning, and expert analysis have been expended, so that each component may lose its complexity to the worker who is required to build it. Unfortunately, the average worker fails to realize that an act of carelessness in observing the explicit instructions concerning his part of the work may lead to failures in the assembled units sometime during the life of the airplane.

In spite of all precautions, difficulties do arise, which it is the function of the inspection department to locate and report. This calls for teamwork of the highest order between shop, inspection, and engineering staffs. Vigilance in detecting errors must never be allowed to lapse, and co-operation between departments to avoid their recurrence must be maintained at a high level. When matters of design are involved, the engineering department must make the final decisions, based upon scientific principles and sound engineering practice.

RESPONSIBILITIES OF MANUFACTURING, INSPECTION, AND ENGINEERING DEPARTMENTS

When difficulties do occur and salvage of manufactured parts becomes necessary, the relation between the manufacturing, inspection, and engineering departments must be on a practical and fully co-operative basis if a satisfactory solution is to be developed.

The first problem is to ascertain the true cause for the damage. Repairing any part would be of no avail if the cause for rejection were not immediately determined and rectified. Among the usual causes of parts failures may be included inadequate instructions to employees, improper use of tools, lack of tools, improper use of jigs or fixtures, condition of tools, and the like. Unless these and many other items are carefully planned in advance and maintained at an efficient level, it is only to be expected that the necessity for salvage proceedings will occur frequently.

During salvage operations, the inspection department assumes an important role. With each group of inspectors who have been trained thoroughly in a particular phase of the construction, there must be at least one experienced inspector who is qualified to evaluate the effect of the damaged part on other assemblies, or on the general functioning of the airplane as a whole. The primary function of the inspection department is to detect errors and omissions yet, oftentimes, questions arise which require engineering approval. In the matter of selecting suitable materials for repairs, it is important that the engineer specify exactly the material to use. The project engineer is oftentimes called upon to advise on the applicability of the damaged part for further use in a given assembly. Items which appear to be unimportant and perhaps nonessential to the inspector may have a far-reaching effect which the engineer alone can see. This is especially true in the matter of accumulated tolerances in hydraulic systems, for example, or in accurate machined fittings where play in the joints cannot be tolerated. The structural engineer becomes the arbiter in all matters pertaining to repairs of airframes and related parts. Whereas the inspector would consider it wise to strengthen a joint by adding additional rivets, the structural engineer would advise against such a procedure because of the reduction in area which ensues in the attaching part. It is true that quite a few structural repairs can be specified on a general basis. Still it is important that, during the manufacturing stage, questions of this nature should be referred to the structural engineer for approval.

ANALYSIS OF DAMAGE

In making an analysis of the damage, it is too often the case that only the local effects are investigated without regard for the far-reaching effects on the completed assembly. On the one hand, the local effects may concern a series of poor rivet holes, whereas the over-all effect on the assembly would mean a redistribution of shear transferred from one web to another.

In like manner, the attachments of stringers to bolting angles is worthy of attention. While the attachment of a single unit may be a local matter, the over-all effect on the bolting angle would be a redistribution of the load normally carried by the stringer to adjacent members. The latter may already be loaded to a maximum. The same applies to rivets driven in oversized holes in sheets wherein the rivets do not completely fill the holes. It is obvious that relatively large shear deformations would result in the repaired sheet, thus causing adjacent portions of the skin to carry excessive loads. The attachment of fittings to longerons, spar caps, etc. is another item in which both local and over-all effects must be considered.

While it is not expected that items requiring extensive repair will be dealt with during manufacturing, it must be remembered, when such is the case, that the over-all properties of the shell-type structure must be kept intact. It is possible, when repairing a wing for major damage, that replaced oversized stringers, if permitted to extend over a considerable portion of the span, will affect the entire bending rigidity of the wing panel. It is not expected that the ordinary inspector would perceive such ultimate effects on an assembly. Hence it is necessary that a close liaison be maintained between inspection and engineering.

Prior to any repair, it is essential that extensive inspection be

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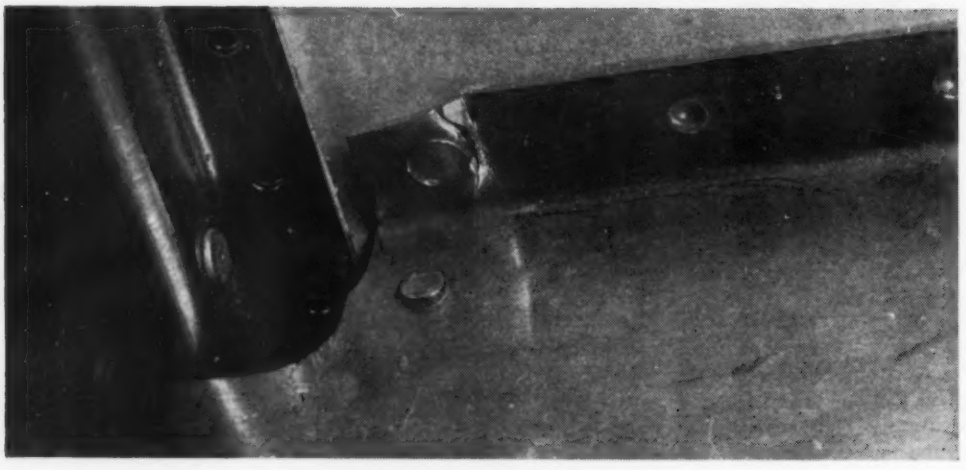
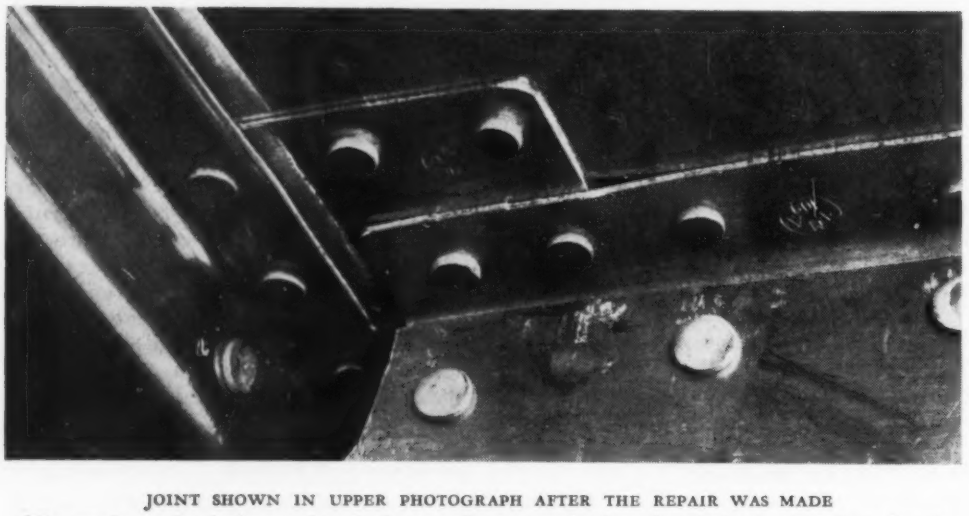


A TORN FLANGE BEFORE REPAIR
(Break which occurred in the flange of a frame.)



JOINT SHOWN IN UPPER PHOTOGRAPH AFTER THE REPAIR WAS MADE
(The repair consisted of removing the bent-up flange completely and replacing it with a formed angle riveted to the web by an additional row of rivets as shown.)

carried out to guarantee that all critical items have been considered. In most riveted assemblies, it is not possible to inspect a riveted joint to detect the amount by which it is sheared if such is the weakest element. It may be necessary, therefore, to drill out occasional rivets in order to check this point.

Another failure that is difficult to detect without further disassembly is a bearing failure. Bearing failures, if left unchecked, will act the same as elongated holes and thus precipitate looseness after the reworked part has been placed in service. Therefore it is the duty of the inspection department to establish carefully the fact that all damage has been found and accounted for. A major repair usually calls for a secondary inspection to be made by engineering personnel. This is for the purpose of double checking the general inspection and making sure that none of the aforementioned items have been overlooked. It is sometimes best that an inspection be carried out by an inspector and an engineering representative on the spot, and a repair worked out which will prove most satisfactory when considered from all angles.

In making minor repairs (and in these may be included repairs which occur most frequently), it is possible that the inspector alone can designate the type of repair to be made, with the aid of a "Structural Repair Manual." The inspector must be able to detect the similarity between the damage at hand and the one illustrated in the manual for which a standard repair exists. With proper interpretation, the inspector may apply the general repair to slightly different cases.

Ordinarily, in analyzing damage to a part or assembly, the following points should be observed: The repair must restore the part or assembly to a condition which is the structural equivalent of the original; it must be interchangeable, and it must not require additional loose parts easily forgotten on reassembly.

Shopworkers and inspectors alike find it difficult to evaluate damage. They often become pseudo stress analysts in order to minimize the case. The rudiments of structural design are little known to manufacturing personnel. However, there are a few rules which, if adhered to, will lead to a better understanding of the problems that are involved. These ten laws might well be termed the "Constitution" of the salvage inspector:

1 The focal point of a highly stressed structure is the joining of two main assemblies.

2 Stresses in any assembly such as wing, empennage, alighting gear, nacelle vary from a minimum at a point farthest removed to a maximum at its attachment to another assembly. (Thus, in a cantilever wing, all stresses increase from the wing tip to the fuselage joint.)

3 The paths of high stress flow can be detected by the nature of riveted or screwed joints.

4 Changes in stress flow can be detected by the increase or decrease in rivet pitch.

5 The members carrying high concentrated loads can be detected by their nature or by end fittings and attachments.

6 All surface material exposed to the air stream is subjected to air-pressure loads. (This includes "unimportant" engine cowling and fairing.)

7 Bolt sizes are an indication of the loads transmitted through them and the margins are seldom excessive.

8 Do not overestimate the strength of steel parts; they, too, have limiting strength.

9 Do not underestimate the importance of screw-attached cover plates; it must be assumed they are designed to carry loads.

10 Remember that the repair always requires greater skill than the original operation.

STEEL-TUBING REPAIRS

Even though few steel-tubular structures are used today, it is still necessary to repair engine mounts, fuselage, turnover trusses, etc. Typical forms of damage may be dented tubes, tool abrasions, cracks, or inclusions in the material itself. The dents or scratches are frequently due to maltreatment during fabrication. Tubular members are often warped considerably during fabrication. Small dents in tubes are usually not serious. If these are no more than two diameters in

length and one-tenth diameter in depth, no replacement is necessary. Abrasions, such as scratches and toolmarks, need individual consideration. A shallow abrasion may be carefully burnished, whereas the more serious type requires replacement of the tube. It is also true that slight eccentricities over the length of a member may likewise be considered as not too serious. This is true by virtue of end fixities at the welded joints. However, no general rules for the acceptability of eccentric tubing can be specified without a complete knowledge of the problem at hand.

In general, splices in a tubular member should not be made in the middle of its length. This general rule is considered mandatory, in that welded splices in this region of a tubular member in compression would distort the tube to such an extent that its usefulness as a compression member would be in doubt. It is also considered wise to make only one repair in any bay of a structural member. Whenever a tube must be removed at a joint, care must be exercised so as not to disturb any other members terminating at the joint. Whenever a member is damaged so close to a joint that it is impossible to retain a stub to which another member can be attached, that member should be replaced entirely. In the case of a continuous longeron, a splice should be made in an adjacent bay.

In general, no butt splices of any member between stations should be permitted. The accepted form of splice is the 30-deg scarf used in connection with an inner liner. If other dimensional conditions exist which make it necessary to use the 60-deg-included-angle fish-mouth type of joint, this may be used. However, it is pointed out that the 30-deg scarf should be used wherever possible.

One of the greatest sources of trouble in welded steel-tubular assemblies is the presence of cracks. The causes of cracks are fairly well known, the more common being an unequal distribution of heat, an unequal rate of cooling adjacent to the weld, poor welding technique, the restraint of a member during welding, or a high carbon content of the steel. When cracks appear, it is considered satisfactory, in the majority of cases, to remove the weld adjacent to the crack and to reweld, taking care that in the ensuing operation no additional cracks will form elsewhere in the joint. Cracks may be rewelded by using the following technique. Regardless of whether the crack occurs in an arc-welded or flame-welded joint, it is best to preheat the metal to a glowing red and then to apply an arc weld to fill in the crack. Through preheating, the rate of cooling is thereby made more uniform and will prevent additional cracks from forming. Unless the members are preheated adjacent to the joint, the arc or flame striking a relatively cold mass of metal will only precipitate additional cracks adjacent to the one being corrected.

MACHINED PARTS

Machined parts, most of which are fittings, require great care and attention when salvaged. Since there are few aircraft fittings subjected to pure stress, a thorough investigation for each case is necessary. In reporting fittings for salvage action, the inspector must report all details including actual dimensions, accumulation of tolerances, surface finish, etc. Without these data, the salvage engineer cannot completely appraise the value of the damaged part. Salvaging machined parts requires a slightly different technique from that used in rendering sheet-metal assemblies usable. Whereas, in the latter, new material is often added, machined parts are frequently salvaged by the removal of material. The resulting part is therefore a structural equivalent and interchangeable part, but not an identical one. Whether a part is completely machined from raw stock, or only partially as in a casting or forging, the problems are the same.

Proper interpretation of tolerances is one of the fundamentals of sound inspection. Accumulation of tolerances is one of the most difficult items to control. Whereas most parts are designed on the basis of nominal dimensions, some judgment on the part of the inspector is necessary in interpreting tolerances. On such parts as lugs and single-bolted attachments, the original strength check should embody all possible tolerances as a safeguard against mismanufacture. Where adverse tolerances have accumulated, it is necessary that the salvage engineer employ all means at his disposal in checking the part. He must check the reduced sections by determining the critical combined stresses. Tolerances may be easily overlooked by the detail draftsman. As a result, it may be necessary to scrap some finished parts or defer them for alternate uses.

Accelerated production has introduced many new problems. Surface finish ranks among the worst that have been encountered. In most aircraft fittings and parts, a smooth machine finish is required. This is necessary to eliminate stress concentrations so far as possible. It is stress concentrations which cause fatigue failures and failures due to impact loads in service. It is remarkable how widely interpreted is the term "smooth machine finish," designated by the symbol "f_8." This has been a relative term, that is, relative to suit the requirements for the use of the finished part. In the past, many machinists and inspectors have interpreted this to mean any surface showing from 100 to 125 toolmarks per inch. For most types of machining, this gave a satisfactory surface.

With many new vendors entering the aircraft field, a finer definition has had to be found. Until the present time, the terms, "Smooth machine finish," "rough-grind," "grind and polish," "hone," etc., have been augmented by physical samples supplied the vendors. However, with the coming of the profilometer and the Brush analyzer, more exact definition is now possible. By defining the surface finish in terms of microinches (millionths of an inch) more uniform conditions are thereby guaranteed. Thus it is seen that the term "smooth machine finish" may now be considered to be a surface having a root-mean-square variation of 250 microinches.

Rough toolmarks should not be permitted to exist in any highly stressed part or in any part having abrupt changes in cross sections. Sharp-cornered notches are stress raisers regardless of the types of stress involved. Many fatigue failures have been traced to coarse toolmarks left in machined parts. Dull tools account for the majority of parts rejected because of toolmarks.

One factor that is most disheartening to the salvage engineer is the stamping of part numbers on carefully machined fittings. It is an accepted practice to specify the location of part numbers on such items as castings and forgings. On machined parts, however, this practice is never too well carried out and, as a result, part numbers are frequently stamped in critical locations. These stamped part numbers are equally as dangerous from the fatigue standpoint as rough toolmarks mentioned earlier. Care must be exercised by machine-shop and inspection personnel alike in selecting the proper space on a fitting for stamping the part number. In any event, it must never be placed in necked-down sections near fillets or other abrupt changes in cross section.

In the matter of castings, it has sometimes been observed that attempts are made to hammer castings into shape. Unless these are of malleable materials, the hammering of castings should not be tolerated under any circumstances. Repeated cold-working by hammering has an injurious effect on the casting, resulting in internal cracks. In the same category, structural aluminum-alloy and magnesium castings should not be welded. Much has been said lately of the X-raying of nonferrous castings. Data are still being collected on the effects of internal porosity, shrinkage, cracks, dross, and other injurious defects on the general strength of the casting as a whole. With the present material factors being used, the general strength of the casting is not greatly impaired. However, with a possible reduction in the casting factor used in design, strict X-ray examination will be required.

Concerning the matter of fillets, there is nothing more important to the fatigue life of a machined part than generous fillets. Oftentimes, it is better to undercut a corner with a smooth-radius fillet thereby reducing the section thickness rather than to permit a sharp corner to exist. Stress concentrations at sharp corners are very serious and their removal by means of undercutting to a slight radius will greatly alleviate the danger of fatigue cracks occurring.

Undermachined lugs offer one of the greatest causes for salvage action. It is well to keep this in mind in designing these items. Otherwise, the only recourse is total scrapping of parts. Lugs with elongated holes may be bushed if sufficient material exists. The minimum practical bushing thickness up to 1 in. OD is $^1/_{16}$ in. In some special instances, $^1/_2$-in. $\times$ $^1/_{32}$-in. steel bushings have been used successfully. Tight press fits must be employed to prevent loss of the bushing in service. Sometimes it is necessary to use stepped bushings with the shoulder placed next to the mating part to prevent loss.

It frequently happens that holes are misplaced by a small amount. The suggestion is frequently advanced by the shop merely to plug the hole and redrill in the correct location. Because of the ever-present possibilities of rotation of the plug with its eccentric hole prior to or during disassembly, this practice should not be permitted. Instead, if a plug is used, it should be inserted concentric to the properly located hole.

Concerning the repair of steel forgings, attention must be given to such imperfections as cracks, pits, insufficient metal at bosses, lugs, etc. Steel forgings may be welded both before or after heat-treatment but the position of the weld depends upon the state of stress in the forging itself. It is possible in some locations to use electric-arc welding without affecting the heat-treatment of the adjoining sections. Where heat propagation must be held at a minimum, it has been found satisfactory to wrap the forging with wet asbestos and thereby prevent nullification of the heat-treatment on near-by sections. Cracks must be distinguished from cold laps; but once identified, they must be ground smoothly until the depth of the crack has been determined. This grinding out of the crack frequently leads to abrupt changes in cross section. Removal of a crack in a fillet must be carefully done and a smooth fillet must remain after the crack has been removed. Slight etching of the forging will sometimes be necessary to determine the extent of the crack.

Difficulties are often encountered in completely machined parts which have not been heat-treated to proper strength. Wherever handling of the part permits, it has been found possible to restore the proper strength through reheat-treatment in a constant-atmosphere furnace or by the following method: The part may be copper-plated to a convenient thickness and then reheat-treated, after which the copper plating may be removed by subsequent machining. This process has been used successfully in a number of cases and the rejected parts thus restored to use. Unless one of these methods is used, it is impossible to heat-treat parts which have reached their finished dimensions due to the effects of surface scale.

Cold working of parts, whether steel or dural, should not be promiscuously practiced. It has been found possible to straighten 24S-T aluminum-alloy bar stock by preheating to a low temperature not exceeding 450 F. This low-temperature heating facilitates the plastic flow of the metal during straightening operations and does not affect its strength. As a means of controlling the temperature accurately, it is suggested that the use of tinfoil be used on the part requiring rework. Thus when the part is heating, the tin will melt at 450 F which is an indication to the workman that the metal has reached its proper temperature for further forming. Considerable forming can be performed in the aluminum alloys at this temperature, especially such as removing wavy deformation in thin protruding flanges. Shop foremen and inspectors alike must be on the alert to prevent reforming of either aluminum-alloy or steel parts successively after initial forming has taken place.

SHEET-METAL REPAIRS

Sheet-metal repairs rank high in salvage operations. This may be due to the inexperienced help now required to do most of this type of work.

The first step in working out suitable sheet-metal repairs is to have a complete knowledge of the materials used in the assembly. It is important, for example, to determine whether the aluminum-alloy sheet is Alclad, bare material, or in the SRT condition. The same applies to the rivets used. It must be determined whether they are A17S-T, 17S-T, or 24S-T, so that the actual repair will utilize the same materials and strength as the basic constituents. Where bare aluminum-alloy material is used, it is necessary to anodize each part in order to prevent corrosion. In executing any repairs on sheet-metal structures, workmanship plays an important part.

Skin splices are sometimes made for a number of reasons. These may include original damage or removal for accessibility to some internal structure. Whenever it is necessary to splice in a new piece of skin covering, inspectors should be guided by its location. As long as they have any choice in the matter, they should refrain from making splices near heavily riveted joints, such as occur along the main spar flanges, or at wing-bolting angles. The form of joint should be in keeping with the type used throughout the assembly.

Concerning the matter of riveted joints at the splice, the inspector must be guided by existing riveted joints in close proximity to the desired one. It would be possible under exact stress-analysis conditions to set forth standard riveted joints for each thickness and type of material used. However, in the majority of cases, such joints would be cumbersome and unnecessarily heavy, since the strength of the joint would be predicated on the maximum allowable tension and shear stresses.

In the case of fuselage-skin repairs, cognizance must be taken of discontinuities such as window openings, doors, escape hatches, etc. In ordinary stress analysis, the structural engineer generally utilizes the structure existing within one frame length of either side of the opening. Inspection of most shell-type structures reveals that close rivet spacing, doublers, gussets and other reinforcements are used in the vicinity around any opening. Therefore in making skin repairs in these localities, structural-engineering assistance is a necessity.

Accessibility in making skin repairs must be had either through existing handholes, removable cover plates, etc. However, where the inside surface of the skin is not exposed through such openings, it will be necessary to add a handhole to make it accessible. The recommended type of handhole is the oblong type and calls for good workmanship when it is installed. This type of handhole must be of the stress-carrying type, that is, it must be screwed in place so as to permit continuity of the skin across the improvised opening.

When skin splices are made between frames or ribs, it is structurally unsound to make a simple lap or butt joint without some materially stiff backing plate to prevent the joint from being deformed. Wherever it is necessary to make such a joint, a gusset plate of the same-thickness material as the wing skin, or one gage heavier, should be used under the joint. This backing plate should preferably have flanged edges to add greater stiffness.

In assemblies where the skin has been predrilled and thus serves as a template for aligning the rivets in a seam or at stringer attachments, errors sometimes arise in the location of the stringer. Then when drilling the stringer from the skin, the holes will oftentimes not be in the desired location and will leave low net edge distances on the stringer, or pierce through the fillet. In the former case, the small net edge distance will result in deformed stringer flanges when riveted. Should this become serious, the stringer should be replaced. In the latter

case, a satisfactory repair in use for some time has been to insert a solid bar of the same material which has been closely fitted to the fillet radius and whose depth equals that of the height of the stringer. Then with the use of an extra-length rivet or screw, as the case may be, the formed rivet head or nut will rest on the block and thus not be limited by the minimum space existing through the fillet.

One of the most common forms of sheet-metal difficulty is the matter of edge distance for riveted or screwed joints at the edge of a sheet. This may not be determined until the complete assembly nears its final stage and then it is too late to scrap a piece of skin and use one which will guarantee proper edge distance. When this occurs, the potential failure is avoided by adding a doubler at the edge of the sheet, lying underneath the leg of the stringer or frame connecting the edge of the original skin. This doubler should extend away from the original joint and an additional row of rivets used to transmit part of the skin loads to the doubler, thus placing the joint rivets in double shear and bearing instead of singly. The net edge distance for any given material, and thickness and size of rivet or screw, can be specified in advance and used as a guide in making repairs. The standard net edge distance may be based on the maximum rivet or screw strength.

Rib splices are relatively simple repairs, that is, ordinary ribs, subjected merely to air loads and not carrying any concentrated stresses. This includes bulkheads at landing-gear installations, through the nacelle or at the attachment of control-surface hinge brackets. In the first-mentioned type, for repairs to damaged flanges, whether at lightening holes or at the attachment to the skin, gusset plates serve a very useful purpose.

In making longeron splices, the original criteria may be applied most generally, that is, the longeron stresses will increase toward the focal point of the fuselage. Here again, it is necessary to ascertain the type of material used. Butt splices are usually resorted to, using generous doublers and liners to transmit the load across the joint. In this type of splice one precaution must be carefully observed, i.e., any splice plate added to the assembly should not be joggled between the two main segments of the prime member. Joggled plates do not operate as effectively as flat sheets.

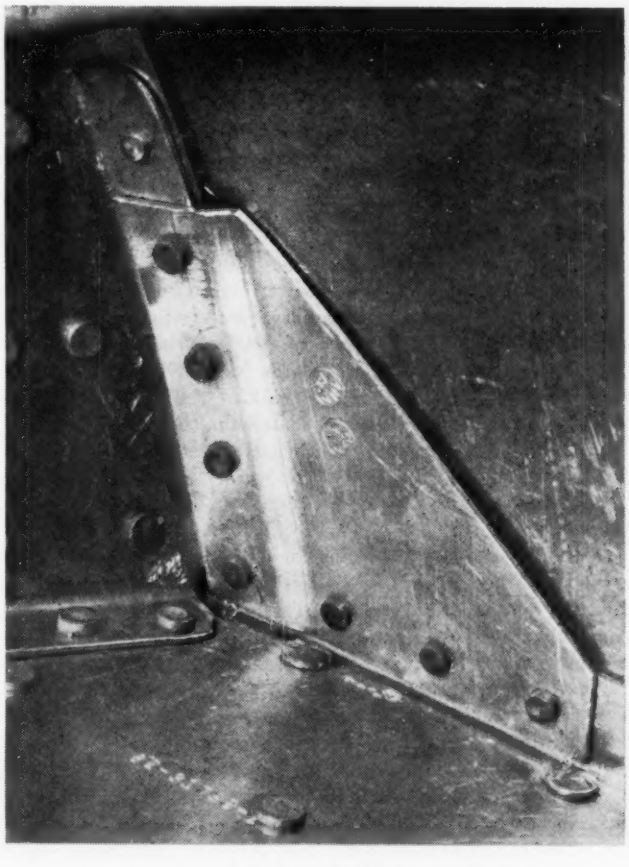
Cold reworking of any aluminum-alloy sheet in the heat-treated condition must be avoided unless so directed by the salvage engineer. Too often sheet-metal parts are reworked to proper dimensions or form without specific authorization. This practice cannot be too vehemently condemned. Internal strains and subsurface cracks are caused by this operation which can greatly weaken the part or reduce its fatigue life. It is better to anneal the material to the SO condition before proceeding on any reforming operation.

The effects of cold reworking of sheet-metal parts are often manifest in flange cracks occurring in the radius. Oftentimes, these cracks result in open breaks during riveting operations on assembly. When this occurs, it is necessary to cut off the flange entirely in the affected zone. A filler plate must then be used in place of the original flange and an angle of the same gage and material substituted.

One common form of salvage operation is the elimination of so-called "oil cans" in skin surfaces. The accepted cure is the addition of light stiffeners in the affected areas. Simple as this repair may seem, some basic principles must be observed. If the original skin is found to be generally loose, it is advisable to remove the rivets from at least two sides, stretch the skin and rerivet using the next-larger-size rivets. Even though residual buckles appear to be severe deformations, the actual change in length due to stretching and reriveting is small. Hence it is often possible to carry out this operation.

Plug patches are frequently used to repair small defects in sheet-metal assemblies. First the damaged area is cut out, using the least-diameter hole necessary. A plug of the same thickness and material as the basic skin is then fitted to the hole.

CASE OF A FORMER FLANGE HAVING INSUFFICIENT NET EDGE DISTANCE FOR RIVETING



GUSSET PLATE ADDED TO REINFORCE THE CONNECTION SHOWN IN THE UPPER PHOTOGRAPH

This plug is in turn spot welded (preferably) to a square or round gusset plate having at least twice the dimensions in all directions as the hole cut in the skin. The gusset-and-plug assembly is then securely riveted to the skin.

When repairing a rib or frame originally having formed beads, it is considered permissible to substitute a suitably formed stiffener for the bead. This holds true in instances when the original beads are subsequently removed during salvage.

RIVETS AND RIVETING

The use of riveted joints in airframe construction has been universally adopted. Three main types have become the accepted standard form but some variations are still to be found in the material used. Particular reference is made to the brazier head, countersunk and flat-head rivets, and the use of A17S-T and 24S-T rivets. The relative merits of countersunk rivets having 100 or 78-deg heads will not be considered. The general characteristics of well-driven rivets have been reviewed from time to time. However, inspection standards still vary. Characteristics which are considered grounds for rejection include severely cracked heads, thin heads, goitered shanks, mutilated heads, set cuts, undriven heads, countersinking too deep, and overdriven heads.

The cracked head is mentioned because in the case of 24S-T rivets, the material in the rivet may become cracked while being driven. Cracked heads are conducive to water seepage and surface roughness, resulting in future damage. The thin head is not recommended in view of the fact that tensile stresses are set up around the periphery of the head and subsequent cold working may cause the thin heads to fail in service. Goitered rivets or swelling between sheets should not be permitted because of local eccentric moments acting on the rivets and serious surface irregularities that will ensue. Some loss in efficiency can also be realized with this type of rivet.

Mutilated heads, like thin heads, are conducive to service failure and must be removed. Rivets with set cuts should be removed in view of the fact that the head material has been reduced and the strength thereby seriously affected. Heads that have been mutilated by set cuts are usually the rivets that "pop" in service. The underdriven head should likewise be removed for the reason that improper driving on the two or more sheets joined will promote looseness. Slightly cracked heads have been a controversial issue but it is now generally accepted that slight cracks do not impair the efficiency or strength of the rivet. This, however, should not be taken too lightly, and rivets having more than a few mere incipient cracks should be removed. Rivets that are countersunk too deeply in the sheet are a serious menace to the strength of the riveted joint. Fatigue failures and looseness of the joint will develop in service. Overdriven rivets, in the case of the A17S-T material, result in a severe swelling of the sheets in the immediate vicinity of the hole. This swelling may be sufficient to deform sheet metal and even extruded stringers. In the case of other rivet materials, the overdriven rivets frequently result in cracked heads.

In general, an inspector must never take the attitude that a few poorly driven rivets in a cluster of many are of no concern, since it frequently happens that such rivet loads are high. There have been ample evidences on all makes of airplanes in service to warrant special care in inspecting riveted joints.

One of the most common causes for rejection lies in how the rivet, itself, fills the hole preparatory to riveting. The most serious of these difficulties is the oval or oblong hole. A careful riveter with a fair amount of experience can satisfactorily swell a nominal-size rivet in an oversize round hole but seldom succeeds when the hole is oval. Most frequently, oval holes can be corrected by using the next-larger-size drill and, unless the hole diameter has been increased more than approximately 15 per cent, the nominal-size rivet can be inserted. For larger holes, it is necessary to resort to the next-larger-size rivet. It is a common practice, where a mechanic wishes to insert additional rivets in a group, to carefully burr the hole after drilling. This should not be permitted since the affected bearing area of the sheet is thereby reduced. Severe burring of holes may be grounds for rejection.

When riveting a sheet to drawn or thin sheet-metal rolled stringer sections, where both the stringer and the skin have been dimpled, it occasionally happens that the swelling of the rivet head causes the dimpled stringer to crack under the driven head. These cracks propagate very rapidly and are a source of trouble when the stringer material has been received in the hard or upper limit. Where the cracked dimples are consistent, it is recommended that the stringer be removed entirely. Where the cracked dimples are sparsely separated (approximately 1 in 10), it has been found practicable to use a special steel washer having a recess to fit over the dimpled stringer. It is considered satisfactory to relieve the end of the crack by a small drilled hole and insert the washer over the dimple and then connect the skin, stringer, and washer with a well-driven rivet. The clamping action of the washer will prevent further propagation of the crack.

Rivet set marks in the stringer or skin are a constant menace, although they are frequently regarded by the inspection department simply as poor in appearance. It must be remembered that, in the vicinity of every set mark, the material has been work-hardened and is conducive to fatigue cracks. Where the set marks are an occasional occurrence, slight burnishing may be permitted and the rivet redriven. On the other hand, where rivet set marks are deep and consistent, it is recommended that a new sheet or stringer be spliced into the assembly.

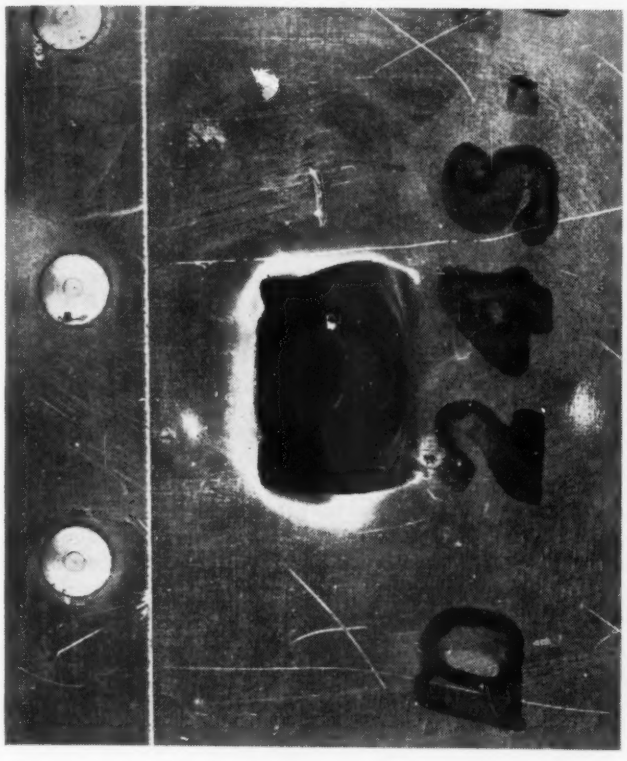
Oversize rivets in present-day airplanes must be regarded seriously. It is not true that all riveted joints utilize a rivet spacing sufficient to permit the use of the next-larger-size rivets indiscriminately. For this reason, it is necessary that any defects in all important rivet joints be referred to the structural salvage engineer for consideration.

STRINGER REPAIRS

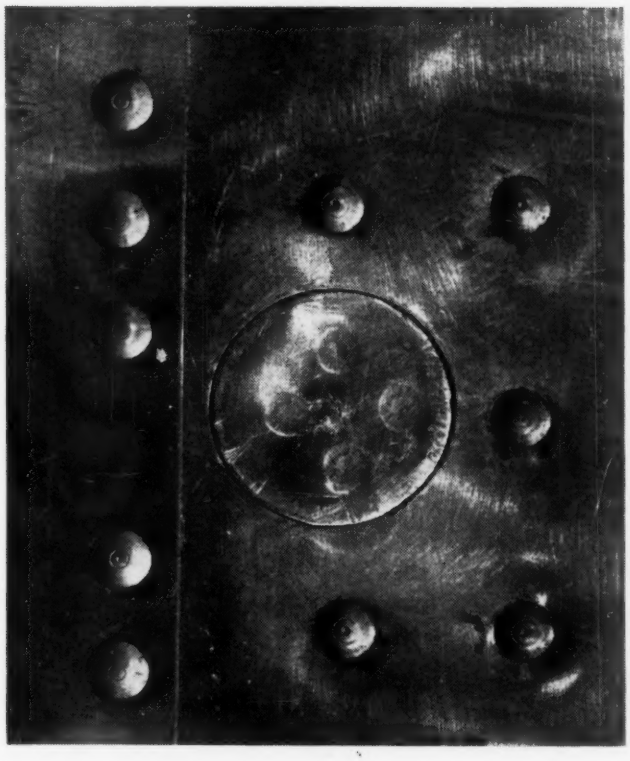
In some salvage operations, it is necessary to replace lengths of wing and fuselage stringer sections. Oftentimes, to the workman, the replacement of a stringer means the replacement of a "skin wrinkle preventer." Whenever a stringer has been damaged sufficiently to call for a complete replacement, a careful survey must be made of the effects which the stringer splice may have on the adjacent structure. In practically all cases, stringers should not be replaced in the end bay of an assembly which contains the continuous joint to another unit. These joints are frequently made through the use of bolting angles which usually result in stress concentrations in the stringers. Hence it is well to replace a longer length of stringer just to keep the splice away from the assembly joint. Stringer splices can be designed on a standard basis by any one agency using a given type. Due to the difference in allowable stress for the stringers acting in tension and compression, and also because of the fact that upper-surface stringers are designed by allowable compressive stresses, splices in the upper-surface stringers will require fewer rivets than on the lower surface. The usual form of stringer repair is by the use of splints, either used singly in the case of plain-angle stringers or in multiple in the case of tee- or hat-section stringers. It has been found practicable to use the adjacent skin as a gusset in transferring loads from the stringer to the splint.

BOLTED JOINTS

Bolted joints are frequently resorted to when high loads are transferred from one member to another, where tension loads may exist, or as a precaution against fatigue. Bolts in joints are more often used in shear than in tension when using



HOLE TO BE PATCHED
(Damage to skin caused by dropping assembly on sharp object.)



TYPICAL BUTTON PATCH
(The button may be clearly seen and represents the appearance on the outside of the sheet.)

standard aircraft bolts to make the attachment. Wherever high tensile loads are carried in a bolt, where the stresses may be alternating or where the loads may be applied through impact, special bolts must be used. The special bolts call for larger fillets between the shank and head and are known to be more fatigue-resistant. Accordingly, when inspecting a damaged bolted joint, it should first be ascertained whether bolts are standard or special. If they are of the former type, some general repair procedures may be followed. If they are of the latter type, special consideration must be given to the case at hand. In the same category as standard bolts, there are now to be found several different types of steel screws which have a clear shank to permit bearing in structural members. These screws, therefore, fall into the same class as the standard bolt but must be limited to applications where little or no tension exists.

The inspection criteria to be followed should include an inspection of the boltholes for size, concentricity, uniformity in depth, whether the mating parts have stepped holes or holes that are burred excessively. In addition, the inspection should ascertain whether the joint is of a mixed variety, that is, bolts and rivets used together, or whether immediate riveted structures are directly affected by the bolted connection. In design, when bolts in shear are used in conjunction with aluminum-alloy rivets, precaution is taken to specify close-tolerance drilled or reamed holes. The reason for this is obvious since the rivets and bolts must work together and not permit one or the other to fail prematurely in bearing or shear. Therefore, the first rule should be that, when adding or replacing bolts, reamed holes must be used.

One of the difficulties in a bolted connection is the ovality of the hole. When sufficient material exists in the part to permit inserting the next-size bolt and interchangeability is not affected, this is the most logical procedure to use. If interchangeability is affected, it becomes necessary to press in a bushing which will correct for the oversize hole and leave the bolt diameter unchanged.

Due to the fact that the standard bolts and screws are really not precision-made parts, it is to be expected that the over-all bolt and shank length will vary. This variation, together with ordinary thickness variations, will sometimes result in bolts or screws having threads in bearing. Good design and existing specifications do not permit threads in bearing. In this repair, several criteria may be applied. When, for example, a bolt is attaching a sheet-metal structure to a relatively thicker fitting, and the sheet-metal part is next to the bolt head and receiving 100 per cent bearing, it is not too serious to allow some threads to bear in the fitting. Still, in another case where relatively thick flanges are bolted together, it is possible that an excess of bearing area exists. Consequently, a criterion can be established whereby the bearing area in any one of the flanges must develop the same strength as the single-shear strength of the bolt. This is especially applicable to cases where an excess of bearing area exists. When the connecting flanges consist of thin sections incapable of developing a bearing strength in excess of the single-shear strength of a bolt, it is necessary to use the next-longer-size bolt with several washers on the outside to prevent threads in bearing.

There is a general exception to threads in bearing, and this is the use of bolts in tension only. A good example of this is the installation of bolts in the connection angles between the outer panel and center section of many wings.

A corollary to the matter of threads in bearing lies in the take-up of bolt threads in nuts, especially anchor nuts. To guard against excessive bursting stresses in anchor nuts, it is necessary that the runout of the thread on the shank of a bolt be not permitted to engage the threads in the nut. To avoid this, the general rule must be: "Do not permit more than two complete threads to show beyond the top of the nut."

Some of the more common sources of difficulty in assembling screwed joints lies in proper countersinking where flush-type screws are used. The principal trouble in countersinking lies in proper care and adjustment of tools. To avoid production

difficulties, it is necessary to maintain a strict surveillance of the condition of all countersinking tools. The second general source of trouble lies in the ability of workers to cut countersink a hole that will be normal to a gradually curved surface. This is sometimes difficult, even with an adequate drill fixture setup, but these must be adjusted to maintain normalcy.

In countersinking bolts with hand tools, a simple expedient is to use a drill bushing which can be held in the hand and rested normal to the curved surface in the immediate vicinity of the desired hole. With the aid of these hand bushings, holes can be drilled normal to the surface quite accurately, and this is the first step in obtaining a good screw fit. Through this hole, countersinking tools having guide plugs can be used to countersink concentrically and in line with the hole. When this is done, ordinary variations can be considered negligible.

In recent years, the question of tightening bolts has received considerable attention and rightly so. This situation probably has developed because of the influx of untrained personnel. In the automotive industry, this problem was overcome by the use of power-driven speed tools of limited torque capacity. Aircraft production, however, does not lend itself to the use of these high-speed tools to any great extent. Consequently, hand tightening is still predominant. A skilled mechanic can tell by the "feel" of the wrench when the nut has been snugged on the bolt. An unskilled mechanic does not have this "feel." Consequently, some standard must be laid down. The standard wrench torque specified for AN nuts is predicated upon the introduction of an initial tensile stress of 40,000 psi on the bolt. It is, however, very easy to extend this value with an increase in wrench torque over that specified. Despite shop intervention to the contrary, the use of torque wrenches will have to continue as the sole means of regulating and obtaining proper tightness of bolts. It must rest with the salvage inspector to determine when slight variations in the standard wrench torques can be tolerated. The latter may be necessary in consideration of the particular installation. In most cases, however, the nut is tightened on the bolt and, consequently, no friction loss is realized between the bolt shank and the hole through the fitting. On the other hand the fiber insert in the nut does cause friction. When the bolthead is used for tightening, there is considerable initial torque between the shank and hole through the fitting. To overcome this initial frictional torque, it is possible that the specified allowable torque for tightening nuts is exceeded. In some instances, this has even prevented the proper drawing together of sheet-metal parts. Obviously enough, such a condition as this cannot be tolerated either by the shop, inspector, or engineer, and some allowance must be made by the inspector to the standard torque required. These excesses in torque over those specified must be determined by practical tests on the installation in question.

CONCLUSIONS

In conclusion, it can be said that structural repair and salvage of airframes during the manufacturing phase is an important matter. The log books containing static-test records are replete with cases showing that it is often the details which determine the ultimate strength of any structure. The successful behavior of a spar web depends upon its attachment to the flanges and support by its stiffeners; the frames and ribs which determine the column length of stringers depend upon the care exercised in forming them; the shear lag in a skin depends to some extent upon the play in riveted joints; the ability of a bolting angle to transfer high stresses depends upon the accuracy of the attachment to supporting members. Therefore it can be seen that each detail is a necessary part of the completed assembly. On these details depends success or failure of an assigned mission.

TYPICAL REPAIR TO A FUSELAGE-FRAME FLANGE WHERE IT ATTACHES TO THE SIDE SKIN

(A flange cracked in the bend radius was replaced by the angle stiffener shown.)

THERMOELASTIC FORMING *of* AIRPLANE PARTS

By W. I. BEACH

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THE aircraft industry, being essentially a metal fabricator, has had very little in common with plastics in any of its various forms. Aluminum, because of its durability, lightness, strength, and ease of fabrication, has been considered the acme of aircraft structural material. Contingent upon these facts, the whole industry has tooled up almost completely with machines designed for metal construction. Consequently, with machines such as the hydropress, drop hammers, bending brakes, and others to help him to fulfill his design requirements, the aeronautical engineer has become more and more metal-minded.

Being constantly reminded of the ever-increasing strength requirements imposed upon the present high-speed airplanes tends to close the engineer's mind to the opportunities offered by certain types of plastics. Such an attitude is justified in view of the fact that, in many instances, poor selection of plastic materials in the past caused needless failures. Consequently, the plastic engineer's task has been a difficult one. Meeting opposition from many sides, he has rarely had an opportunity to prove the suitability of these materials for a great many parts used on the airplane. Furthermore, excessive die costs, high unit prices, and uncertain deliveries did not warrant experimental applications. As a result, the plastic engineer was hard pressed to counter the sound argument deploring the use of plastics as presented by the metal engineers.

The Plastic Section of the North American Aviation engineering department was confronted with an additional problem. Reasonable quantities of the conventional high-pressure-molded parts were being incorporated in production, but very little use could be made of the laminated materials, particularly the thermosetting variety. Fabricated skins and panels requiring simple and compound curvatures were impossible to obtain from flat-sheet laminates. In simple applications such as curved access doors, wherein a flat sheet was held in position by bolts or Dzus fasteners, buckling between attachment bolts invariably occurred. To resort to high-pressure molding of laminated-fabric-base material was out of the question in view of prohibitive die costs. Hence it was realized that a competitive plastic-forming material must be obtained. This sheet must possess good forming properties, lend itself to ease and speed of operation, and permit fabrication with the aid of inexpensive tools. Having these "musts" in mind, the plastic engineers began a research and development program. The result of their efforts was the development of the North American "thermoelastic forming process."

DEVELOPMENT OF THERMOELASTIC FORMING PROCESS

By this process so-called finally cured, or "C" stage, phenolic laminated-fabric-base sheet is treated. It is to be understood that this process is not to be confused with the conventional "B" stage operation performed in the unpolymerized condition or with the low-pressure resin process. The thermoelastic method deals with thermosetting phenolic laminated sheets purchased in accordance with Federal Specification HH-P-256.

It would be well to digress for a moment and discuss the phenomenal results obtainable with the thermosetting laminates.

By common consent the plastics industry segregated the many different varieties of plastics into two distinct groups. The thermoplastic product is noted for its ability to be re-formed by the application of heat. Conversely, the thermosetting type when polymerization is achieved transforms into an infusible and irreversible product. The aldehyde group of plastics, which we customarily accept as thermosetting in character, actually is something different. Hence if this material, defined as thermosetting, is not irreversible or infusible then it must be a thermoplastic or a modification of the thermoplastic group, since there are only two classifications of plastics. According to Delmonte,[1] certain of the organic plastics may be said to be on the border line in so far as the definition of "thermoplastic" and "thermosetting" is concerned. These materials may remain thermoplastic for a long period of time, although ultimately under repeated heating and cooling, or under prolonged exposures to high temperatures, they are converted to a thermosetting material.

Regardless of what type resins Delmonte had in mind when he made reference to the borderline case, it would appear that the cresols and cresylic-acid mixtures would fit nicely in this category. Theoretically, all the thermosetting laminated-fabric or paper-base sheet material offered on the market today is completely cured. According to the Federal Specification HH-P-256, certain minimum properties must be obtained. Hence if the resin-impregnated sheets assembled on a hot-plate press and subjected to pressure and heat were tested in the laboratory and found to satisfy the minimum requirements listed in the specifications, further treatment of the laminates was deemed unnecessary. Many laminators established a market for their product by selecting a particular type of cloth and modified resins. Several of the larger concerns are noted for manufacturing laminated material which possesses a greater resin content, inherent stiffness, and harder surface finish than the materials produced by others.

In any case, irrespective of the policy of laminating companies, it was known that a certain designated heat, pressure, and time cycle would produce the properties desired. It was known also that beyond this point, ascertained as the "cure" or polymerization point, further application of pressure and heat resulted in a very slight increase in strength properties. When the results were plotted, in which heat and pressure remained constant, it was found that the curve flattened and became nearly asymptotic to a horizontal line drawn through the cure point. Thus it was obviously poor policy to tie up press equipment for a longer period of time in order to obtain such small benefits. A final test was to submerge the laminates in an acetone bath. If no dissolving action was apparent then the thermosetting stage was achieved.

In conversation with several prominent plastics men, it was pointed out that it had been known for years that thermosetting

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[1] "Plastics in Engineering," by J. Delmonte, Penton Publishing Co., Cleveland, Ohio, 1942, p. 20.

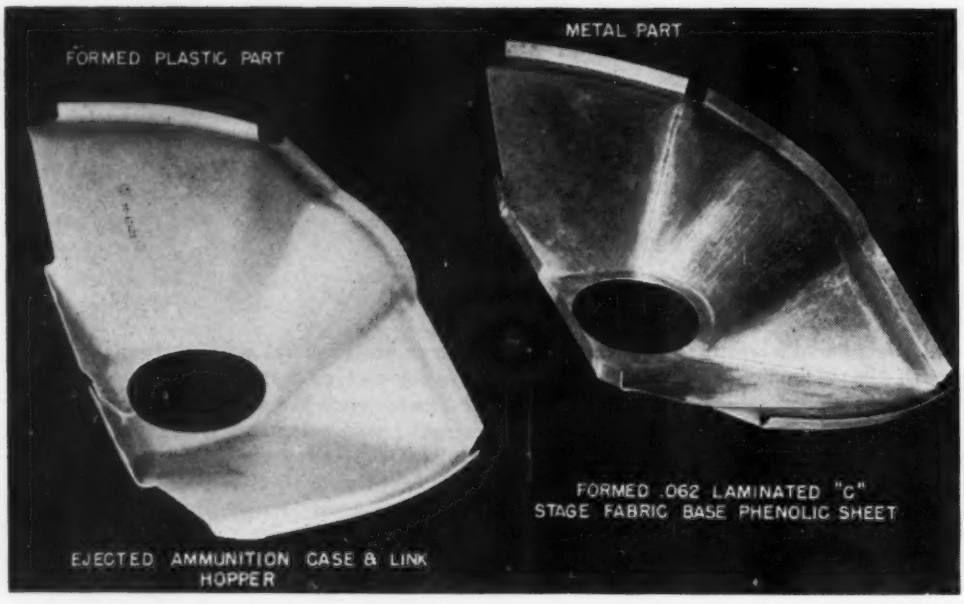
METAL PART
FORMED PLASTIC PART
FORMED .062 LAMINATED "C" STAGE FABRIC BASE PHENOLIC SHEET
EJECTED AMMUNITION CASE & LINK HOPPER

FIG. 1 EJECTED AMMUNITION CASE AND LINK HOPPER

products were capable of a slight softening under the action of heat; but on the other hand, the softening was always followed rapidly by a hardening effect. By and large all of them, when visiting the North American plant to witness the forming work being conducted, have expressed complete amazement at the flexibility of thermosetting laminates. The subject of thermosetting was invariably raised and was acknowledged by most as being modified for the present class of laminates. Some admitted the foregoing observation, but qualified by saying the resin was thermosetting in character and would ultimately reach that point with additional heat and pressure. With at least a fairly comprehensive background of the B stage laminating process presented, an attempt will be made to evaluate the forming characteristics of thermosetting sheets of material.

FORMING CHARACTERISTICS OF THERMOSETTING SHEETS

Remembering that the aircraft industry is accustomed to metal terminology, a brief analogy will be drawn between the aluminum alloys and thermosetting laminates. Any comparison must be relative due to the extreme differences in their physical composition; aluminum is crystalline in structure, thermosetting plastic is amorphous.

In the case of SO aluminum, a bend or draw is accomplished by a corresponding sliding of the crystals along slip planes. It may be said that slippage occurs along any of three axes, depending upon the direction of force causing distortion of the crystalline structure. Although thermosetting plastics cannot be said to possess slip planes, they are not restricted to directional forming. Whereas aluminum deforms by slippage of crystals along planes of weakness, laminates deform by an incremental sliding and stretching of the adjacent layers of fabrics.

With aluminum a draw or bend is generally accompanied by a reduction in thickness at the critical section. The thermosetting material gives evidence of no reduction in thickness and often as not produces a slight increase at the critical bend or draw section. Since the adjacent layers of fabric obviously stretch, the increase in section must be accounted for by a redistribution or expansion of the resin. It is suspected that the expansion of resin is contributed to by a reduction in density.

Due to the fact that SO aluminum possesses more elongation (eight per cent in two inches) than 24S-T aluminum, deep-forming or drawing operations are done with the softer material. Compared to this the thermosetting laminates possess less than one per cent. Yet, when treated properly for forming, the

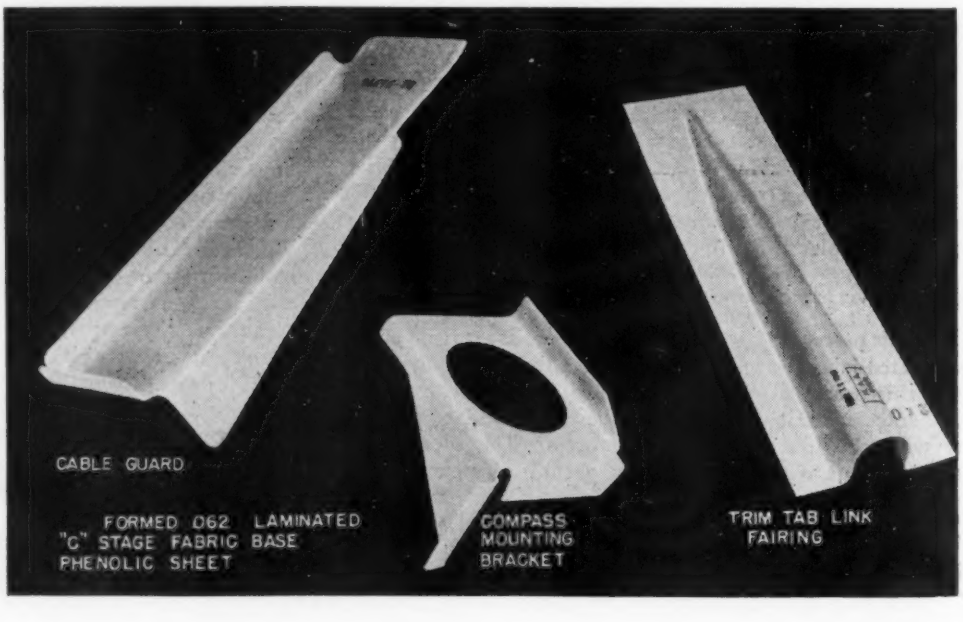

FIG. 2 TYPICAL AIRPLANE PARTS FORMED BY THERMOELASTIC PROCESS

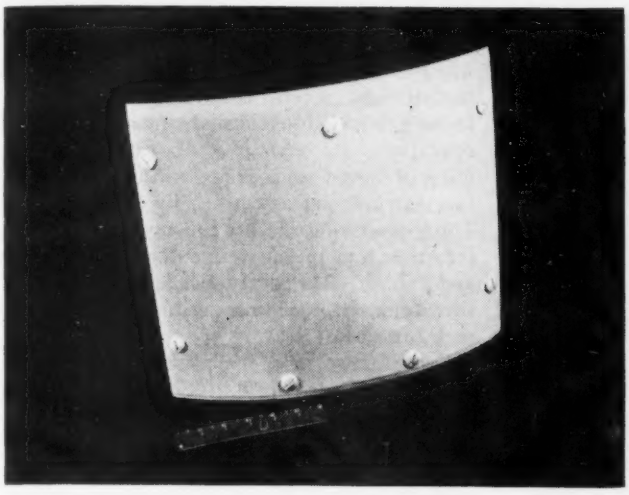

FIG. 3 EXTERNAL ACCESS DOOR

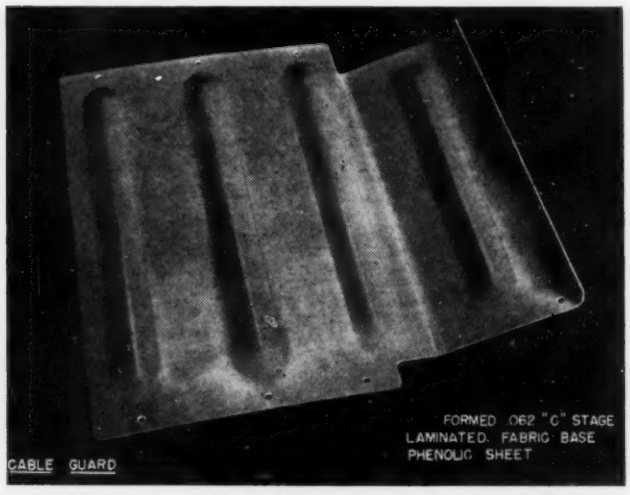

FIG. 6 TYPICAL CABLE GUARD ON NORTH AMERICAN AIRPLANE

FIG. 4 TYPICAL DOME-LIGHT MOUNTING BRACKET

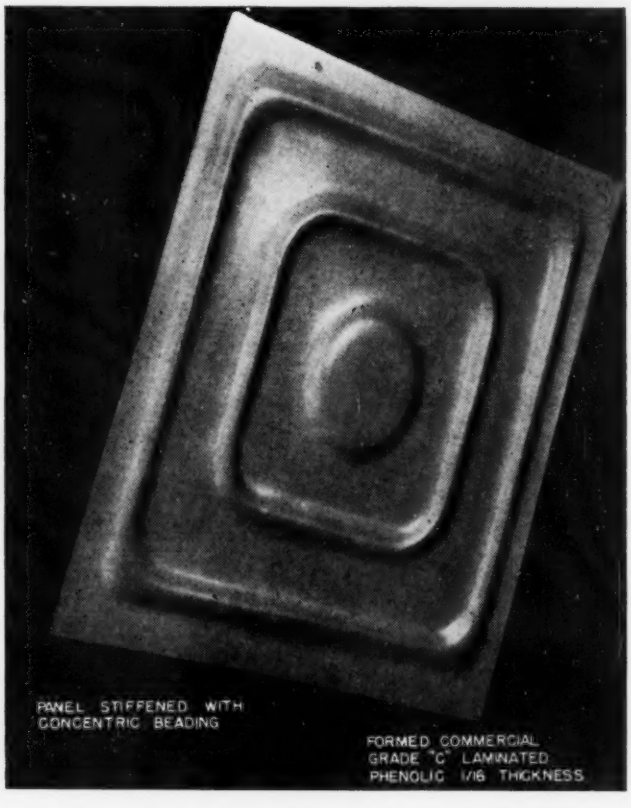

FIG. 5 PLASTIC SHEET FORMED INTO STIFFENED PANEL

thermosetting laminates can be made to form objects impossible to duplicate with 24S-T and difficult to obtain with SO aluminum. North American has several laminated-formed parts in production at present on the B-25 bomber, which demonstrates this fact. Contrary to one school of thought, thermosetting material, like aluminum, tends to gain a slight increase in strength as a result of treatment. Aluminum increases its strength by the cold-work application. The thermoelastic process accomplishes a similar result because it has a tendency to complete further the polymerization, or cure, of the material.

It was pointed out in the early part of this paper that a practical "cure" point was established by the laminators, as sufficient to meet the minimum requirements listed in the Federal Specification HH-P-256. Attention was also called to the possibility of obtaining some improved properties with additional application of pressure and heat, although it cannot be said that all the properties improve with forming because, actually, some reduce slightly. A few incomplete tests (not ready for publication) made so far indicate a very favorable balance. It is believed, however, that, with some slight modification of the resin, an all-round improvement can be obtained.

When the metals are strained within the elastic limit, a return to its original shape occurs upon the release of the deforming force. Consequently, press operations, such as bending and drawing, must deform the material beyond the elastic limit. This is known as the plasticity range. Repeated cold working, due to deformation, increases its resistance to further forming operations. Therefore while aluminum is limited to recurring bend or draw operations due to cold work, the laminates may be formed and re-formed a great many times. It is particularly

FIG. 7 AMMUNITION-CASE DEFLECTOR PLATE

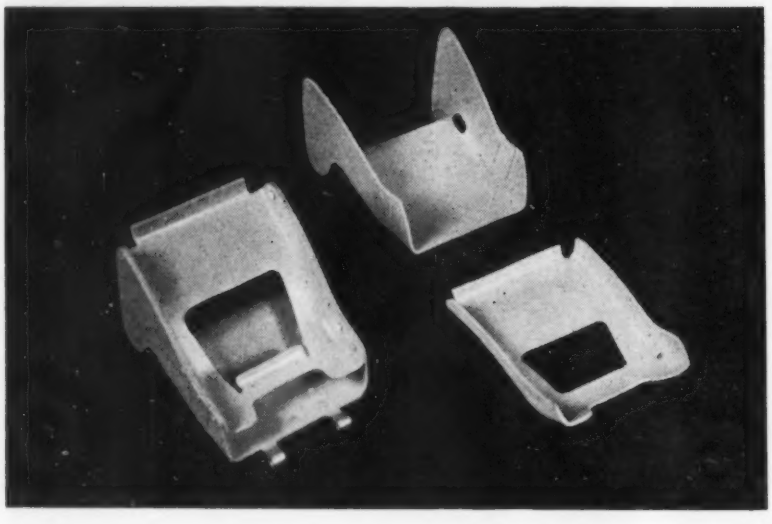

FIG. 8 WING-GUN AMMUNITION-FEED CHUTE

noteworthy that, after each forming operation, the thermosetting material can be made to return to a close approximate of its original form without the aid of applied external pressure. Thus aluminum is formed in the plastic range, and plastic thermosetting materials may be formed in the elastic range.

RELATIVE FORMING CAPABILITIES OF ALUMINUM AND LAMINATED PLASTICS

Once convinced that thermosetting laminates possess good forming properties, the next step involves a shop-operation study. Here it was discovered that plastic-forming offers opportunities for production not often obtained with present metalworking equipment. For purposes of illustration, a breakdown is presented, comparing the relative operations involved in forming a specific part using 52S-O aluminum and phenolic laminated sheet.

Referring to Fig. 1, a representative production part is shown in plastics and metal. Taking first the 52S-O aluminum part, it is seen that four separate sections are seam-welded together. A total of 40 inches of weld were required to attach the four component pieces. Three pieces, the center and sides, required separate forming dies. The fourth was bent upon a brake machine. Consider then the steps taken to produce the metal part. Four flat patterns must be cut from sheet material and routed to specified shape. After the forming operations, the sections must be reworked for wrinkling of excess material which generally accumulates in severe contoured sections. To smooth buckled sections, hammer or beating operations are utilized. At the same time, filing of burred edges is performed. Finally the four sections are assembled by seam welding. Thus, reviewing briefly the operations, it is seen that four pieces were cut, routed, formed, and welded. The total time required to prepare the aluminum part for production amounted to $1^1/_4$ man-hours.

Compared to this, the plastic parts required cutting, routing, forming. In time, it took nineteen minutes to produce an equivalent plastic part for production. Using this comparison for purposes of argument, it may be said then that plastic forming can compete successfully with metal technique. Furthermore, laminates lend themselves to metalworking equipment and, subsequently, can be readily adapted to shop procedures.

By no stretch of the imagination should plastics be considered as a direct replacement material for metals. Promiscuous use of an obviously weaker material would be extremely foolhardy and should be avoided. Although extensive development work now being conducted to increase plastic properties indicates considerable promise, it is best, for the present, to confine plastic applications to semistructural or nonstructural items.

SPHERE OF APPLICATIONS FOR PLASTICS

An airplane when broken down into its component parts consists of structural, semistructural, and nonstructural members. Structural members, or the backbone of the airplane, are intended to support the flight and landing loads. Upon these depends the structural integrity of the design. Semistructural members are those parts which, if failure occurred, would not necessarily be responsible for the safety of the airplane. Nonstructural items are sometimes looked upon as necessary evils. They perform utility functions such as fixed equipment support, ammunition containers and chutes, and various other duties needed to complete the serviceability requirements. Therefore if judicious use of plastics is adhered to in respect to semistructural and nonstructural applications, an important contribution is made to the efficiency of the modern airplane.

In effect, this has long been North American's policy for plastic materials. Precautionary measures are taken to approve its use only when definite advantages are obtained. In other words, plastic parts must be better than their metal counterparts. For the purpose of demonstrating typical parts which may be produced by the "thermoelastic" process, several illustrations are presented for which the following notes are offered for further information:

Fig. 2 shows a cable guard, a compass-mounting bracket, and a trim-tab fairing. All three parts perform functionally in the same manner as corresponding metal parts, while providing decreased cost and weight.

Fig. 3 shows an external access door. In addition to weight saving, the plastic door is more resilient than metal. Consequently, it tends to resist permanent deformation or dents created by rocks sent flying against its surface by the landing-gear wheels.

Fig. 4 represents a typical dome-light mounting bracket.

Weight saving, reduced cost, and resistance to vibrational forces motivated this change to formed plastics.

Fig. 5 serves to illustrate a stiffened panel. Stiffening beads may be introduced in the panel at no additional weight penalty.

Fig. 6 shows a typical example of a cable guard as used on North American airplanes. Changing metal guards to plastics effected a considerable weight saving.

Fig. 7 shows a deflector plate designed of plastic material and formed to exact contours to replace an aluminum plate. Where resistance to abrasion is required, plastics are much superior to aluminum.

When stainless steel became critical, plastic ammunition-case ejection and feed chutes were formed to replace steel. An ammunition feed chute is shown in Fig. 8. Firing tests proved the durability of plastics in this application. Besides, a considerable weight reduction is obtained, plastics being approximately 6 times lighter than steel for equivalent thicknesses.

Fig. 9 illustrates a type of ammunition box used on North American airplanes. The 30-cal box weighs $1^1/_2$ lb less than the corresponding steel box. A plastic formed 50-cal box saves 3 lb over the corresponding metal box. Since a number of these boxes are used per airplane, the weight reduction is notable.

Fig. 10 shows a tail-wheel fairing. When this part was first considered for plastics, a quotation was obtained for a high-pressure-molded part. The molder wanted $8000 for a die, and $27 unit price per piece. Later this part was formed at North American at a tooling cost not to exceed $100 complete, and a unit price of $10.

A comprehensive forming discussion was given earlier regarding the ejected ammunition case and link hopper shown in Fig. 1. However, no reasons were given why the plastic material was considered more applicable than aluminum for the hopper design. The purpose of the hopper is to receive the impact loads of the ejected ammunition cases and links. Experience has shown that aluminum is vulnerable to damage from the sharp edges of the cases and links, and scars readily. Since the hopper was to be permanently installed, a removable liner was proposed to fit inside the hopper. When the liner became too scarred for further use, another one would have to be installed.

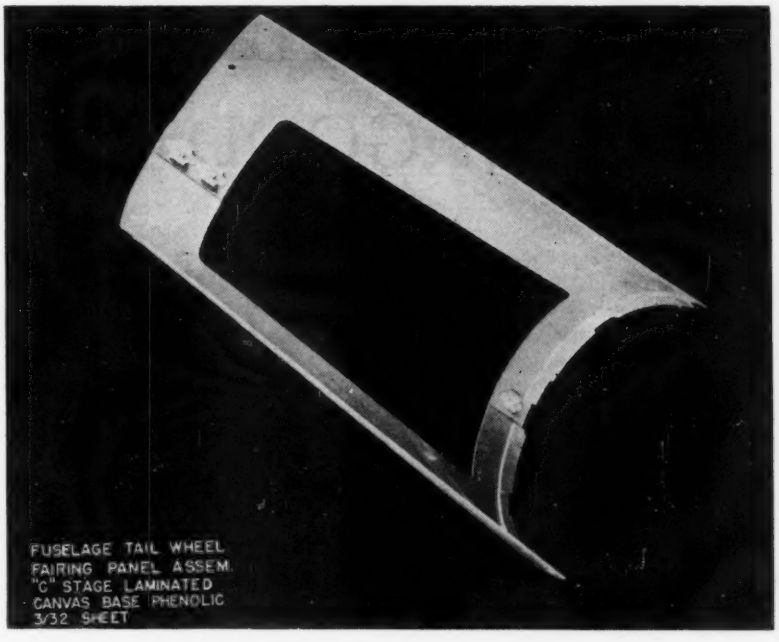

FIG. 10 TAIL-WHEEL FAIRING PANEL ASSEMBLY

A firing test was made with the plastic hopper serving in place of the metal one. After 800 rounds were fired, examination showed evidence of very little wear on the surface. Hence the laminated formed part was considered more suitable for service. An extra part was eliminated, a weight reduction secured, and production man-hours saved, all of which warranted the use of plastic material.

The "thermoelastic forming process" offers possibilities for production which are beyond the scope of this paper. Development work is continuing to improve the technique for present and future projects. Until this work is completed, the author has refrained from discussing the exact procedures involved in forming thermosetting laminated-sheet material. At some later date it is likely that further information concerning this process may be released.

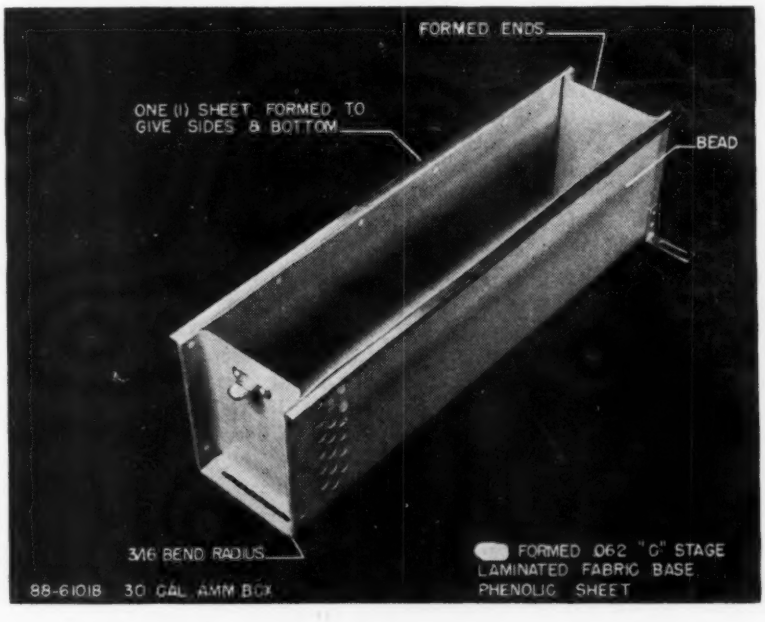

FIG. 9 AMMUNITION BOX

HARD-OF-HEARING WORKERS *Are* GOOD EMPLOYEES

By LIEUT. ROBERT C. BLACK[1]

BIG plants like Ford and Goodyear, as well as many smaller factories, are increasingly using deaf and hard-of-hearing employees as war-production workers. They are not only capable, but as a group results show they have less absenteeism, are more loyal and more safety-conscious than normal employees. There are between 10,000,000 and 15,000,000 persons (1)[2] in the United States who are either deaf or hard of hearing. Of this group, about 3,000,000 are children in our public-school systems (2). Assuming roughly 2,000,000 as being too old or physically unable to work, the remaining conservative figure of 5,000,000 men and women are either working in war industry or can be classed as theoretically potential prospects for war work.

FITTING THE DEAF INTO MASS-PRODUCTION JOBS

Do the deaf and hard-of-hearing workers require special considerations to fit them into mass-production organizations? Speaking from many years of experience, Henry Ford says, "The deaf require no special consideration—they do their work one hundred per cent." (3) Charles W. Sieberling, of the Goodyear Tire and Rubber Company states, "We started with eight deaf workers. Gradually we added more until there was a total of 800 deaf men and women on the pay roll. The record speaks for itself. These men and women proved themselves loyal, safe, and efficient workers."

Why then do most of our deaf and hard-of-hearing workers find employment in nonessential industries or jobs where their skills are not being used to the greatest advantage in our war effort? Perhaps the answer to this question can be better understood if we review the experience of a young deaf graduate of one of our schools for the deaf who was applying for a position as a tracer in a drafting room of a war industry. This young man completed the specialized vocational training in addition to his basic academic education. He was an excellent lip reader and could talk well. The employer who reviewed this young man's application was in another office but within seeing distance of the applicant. The following conversation was read on the lips of the employer as he addressed his secretary: "Sorry, Miss Jones, I can't use this young man. He's deaf and dumb. Please tell him there's no work today." This misinformed personnel manager thought of all deaf people as being "dumb." They have "defective hearing apparatus, but not defective speech organs, and are not dumb." (4) The dictionary gives the literal meaning of "dumb" as "destitute of the power of speech." The use of the word "dumb" colloquially as meaning "ignorant," "dull," and "stupid" has caused the deaf and hard of hearing more hardship than the loss of their hearing. This is in part responsible for the attitude of employment managers in many cases for not placing these handicapped workers on more essential jobs in war industry.

One of the largest pioneers in the placement of the deaf and hard of hearing is the Ford Motor Company, where today there are over 111 totally deaf employees and hundreds of hard-of-hearing workers engaged on all types of jobs, ranging from sweeping floors to the most skilled job of toolmaking. The only precaution considered necessary when placing deaf people in the Ford Plants is to protect them from falling stock by making sure "they do work in buildings where there are no overhead cranes passing over them . . . . . Records indicate that none of them has received major injuries while at work on his respective job."

TYPES OF WORK FOR WHICH DEAF ARE QUALIFIED

What are some of the kinds of work the deaf and hard of hearing are best qualified to do? There are very few jobs that a handicapped hard-of-hearing person cannot do, for in many cases the use of a hearing aid brings the worker's hearing to normal. The totally deaf are unable to overcome their handicap, so they specialize in trades or professions which require no hearing to perform the job. Some such jobs are machine operators as for example, a young man who operates a stapling and stitching machine in a box factory at $43 per week. This 20-year-old worker lost his hearing from the instruments used at childbirth. In another box factory, a 22-year-old worker who lost his hearing while a child from diseased tonsils is a "bundler" and makes $25 a week. A 24-year-old deaf worker with only a third-grade education is now employed with a large radio company spraying copper on metal shafts for radio condensers. After his first three weeks on this spray job he was leading the department in production. He earns about $36 per week. A large valve company hired a deaf boy several years ago who had no previous industrial experience and trained him to test high-pressure valves. Today this 27-year-old deaf employee makes $35 a week at this specialized task.

There are many responsible positions being filled by deaf girls. One of last year's graduates from a school for the deaf is now employed making civilian gas masks at $40 a week. This young lady lost her hearing from scarlet fever while just an infant. Another young woman, a widow at 29, is lining and decorating pottery dishes for Navy contracts and earns $24 a week while she is learning.

Some of the so-called "deaf" are really deafened people who have lost their hearing during childhood or in later life because of an accident or some illness. Such is the case of a very able cost accountant who was one of the country's first in this profession. He lost his hearing from an automobile accident at the age of 45 and with the help of his State Rehabilitation Bureau was able to master the art of lip reading which resulted in his taking over many of his former responsibilities as a cost accountant and today earns an income of $3200 a year.

Many of the deaf have attended college. The Harbison-Walker Refractories Company, the world's largest producer of insulating firebrick, has in its employ a young draftsman by the name of Robert Scherer. Bob was deafened at the age of 9 years from spinal meningitis. He completed his grade-school work at DePaul Institute for the Deaf and was graduated from the South Hills High School in Pittsburgh. The Pennsylvania Bureau of Rehabilitation took Bob's case to the University of Pittsburgh and arranged for him to attend classes in the engineering college. Four years later he was graduated with a degree of Bachelor of Science in mechanical engineering. Today, Bob is on a drafting board helping make the technical layouts for the other branch plants of the company.

An example of an older engineer making good is that of H. A. Travers, consulting engineer in the switchgear depart-

[1] Lieutenant, U. S. Marine Corps. Jun. A.S.M.E.

[2] Numbers in parentheses refer to the Bibliography at the end of the paper.

H. A. TRAVERSE, BETTER KNOWN AS "DOC," IS CONSULTING ENGINEER FOR THE WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, SWITCHGEAR DEPARTMENT

("Doc" has been hard of hearing for the past 22 years. He is shown here working out a complicated relay problem on the direct-current calculator, the design of which he supervised, in the switchgear laboratories.)

ment of the Westinghouse Electric and Manufacturing Company. He has been hard of hearing for the past 22 years. "Doc" Travers is considered one of the ablest electrical engineers in the Westinghouse organization and was among the first to receive the distinguished "Silver W" medal. This medal is awarded for outstanding contributions to the electrical industry and bears the inscription, "whom his fellow men delight to honor." There have been only 265 such awards made out of 99,538 employees.[3]

Recently the Goodyear Company in a press release stated: "Mutes are well-fitted for war production. Over 100 'silents' speeding flow of fuel tanks, other military items" in departments which include "fabric inspection, tires, balloon assembly, tire inspection, gas masks, half tracks for tanks, rims for airplane wheels, spreader room, machine shop, stock preparation, shipping, and many more." "These mutes are among the most assiduous, faithful, and hard working of the thousands of Goodyear employees."

HARD OF HEARING GOOD SAFETY RISKS

There are many questions generally asked by prospective employers of the deaf and hard of hearing. The most popular is, "Don't the deaf and hard of hearing have more accidents than the normal hearing employees?" Experience has proved that the workmen handicapped by partial or total loss of hearing are just as good accident risks as the hearing employees. Mr. I. W. Gangawer, secretary and treasurer of Bethlehem Fabricators, Inc., said, "... our record of deaf employees is just as good as hearing employees in their work, as well as in accident experience."(5) Dr. T. Lyle Hazlett, director, department of industrial hygiene, School of Medicine, University of Pittsburgh, says, "In my twenty years' industrial experience, I am convinced that the accident ratio per deaf and hard-of-hearing worker is much less than the normal hearing employees."

Another question often asked is, "How do the deaf focus their attention on their work when they are constantly looking out for accidents?" Modern production methods are carefully planned by experts, and the "accident occurrence will vary inversely as the degree of attentiveness an employee gives to his particular task." (5) J. L. Vielkind, the superintendent of the H. D. Bob Company, Inc., says, "We can safely say that after once knowing their job, our deaf employees are just as efficient, probably more attentive to their work, than those who have all their faculties."

INDUSTRIAL INSURANCE COVERAGE FOR DEAF EMPLOYEES

Will industrial insurance policies cover these deaf and hard-of-hearing employees at the same rates as for normal hearing workers?" This is a question of general interest to all employers. The answer is "yes," for in most states all first-class insurance companies will provide coverage for these handicapped employees at the same rates as the workmens' compensation law requires. For example in the State of Pennsylvania under the insurance law, "an insurance company is not permitted to limit the coverage of the policy, that is, the policy cannot cover some employees and not all." (5)

ZURA HAYES, A DEAF MUTE EMPLOYED AT THE GOODYEAR AIRCRAFT CORPORATION

(Hayes, a native of Jacksonville, Ill., is one of more than one hundred deaf mutes in the entire Goodyear organization in Akron, Ohio.)

[3] As of January 31, 1943.

Sometimes an employer will ask, "Do you think it desirable to have a few deaf and hard-of-hearing employees?" It seems like good business to safeguard your production system with several deaf and hard-of-hearing workers for there are almost no "floaters." "Of the 243 deaf men who were interviewed," says Warren M. Smaltz, "only 15 had been with their present employers for less than one year. The overwhelming majority had held their positions for more than five years; and 23 of them had given continuous service to the same employers for more than 20 years." Mr. Smaltz explains this unusual condition as being "quite simple. You see, deaf people have great difficulty in obtaining a job in the first place. So when they do get one, they are more likely to value it highly, and stick to it."

"Where can I secure the names of workers trained to fit into the production organization of my business?" In most states, there are bureaus for the rehabilitation of the physically handicapped. These agencies are familiar with the schools for the deaf within their jurisdiction, for each deaf graduate is interviewed upon leaving school. In addition the United States Employment Service has on record a great number of these handicapped applications with a fair amount of information as to the abilities of those deaf and hard-of-hearing persons who are registered with their offices.

GIVE THE HARD OF HEARING A CHANCE IN INDUSTRY

When one stops to consider that it is estimated one out of every ten persons is deaf or hard of hearing, or as a group they would constitute a standing army larger than our present military forces, then the importance of placing this 4-F group of workers becomes more than just idle talk but in reality one of the country's most important industrial manpower problems. Perhaps if your needs are such that you can use a willing worker rather than a "talker" you will give the future deaf and hard-of-hearing applicants a place in your production organization. Today, the deaf and hard of hearing are making good in war-production plants. After taking on twenty-two deaf workers, an official of the Interstate Aircraft and Engineering Company, at El Segundo, Calif., says: "They are making good. Deaf folks have especially nimble fingers which stand them in good stead in close critical work. They are now working on gun chargers and bomb racks."

MISS HELEN MARGUERITE EVANS IS A DEAF MUTE WHO HAS LEARNED TO RIVET WINGS AND OTHER PARTS FROM HER TRAINING IN THE GOODYEAR SCHOOLS

(Miss Evans had no previous experience before she went to Goodyear from her home in Sapulpa, Okla.)

BENEFITING BY THE FORD MOTOR COMPANY'S POLICY OF EMPLOYING THE PHYSICALLY HANDICAPPED, THESE THREE BROTHERS, ALL DEAF MUTES, ARE HELPING WHIP THE AXIS AT THE TOOL BENCH

(Tool grinders in the Pratt & Whitney aircraft-engine division of the Rouge plant, they are, left to right, Horace Waters, 32; Wilbert Waters, 27, and John Waters, 22. Horace has worked at Ford's more than 14 years and lives in Farmington, while the others live in Royal Oak. All are married.)

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PRODUCTION CONTROL

As Practiced at Vultee Field Division of the Consolidated Vultee Aircraft Corporation

By W. V. McCLUNG

SUPERVISOR OF PRODUCTION CONTROL, VULTEE FIELD DIVISION, VULTEE FIELD, CALIF.

THE paramount function of the production-control system to be considered is to assure that schedules are met. To meet schedules, the parts required in correct quantities must be at a predetermined place at a given time, as established mechanically by powered assembly lines geared to minutes.

It is important to understand the relationship of the Production Control Department to the various departments within Vultee Field Division, from the inception of a contract to the completion of the airplanes and acceptance by the customer. A functional chart of the organization setup is shown in Fig. 1.

All contracts clear through the business office where "master authorizations" are written covering the work to be performed as stipulated by the contract. The engineering department creates the design and makes the detail drawings and parts list. The tooling department plans, designs, and builds the manufacturing tools, determines material requirements, and establishes operation planning, all preparatory steps to production control.

The material requirements are forwarded to the matériel department, where the bill of material is prepared, quantities determined, material purchased and received into stock, the warehouses and stores being under its control.

Operation planning for each part is forwarded by the tooling department to the production department, which must determine who is to make the part, i.e., whether it is to be manufactured at Vultee Field Division, contracted for manufacture from an outside firm, purchased as a standard manufactured catalogue article, or provided by the customer (usually the Government furnishes equipment such as instruments or armament).

At the point where the tooling department releases operation planning, the production department assumes responsibility for securing proper material from stores, movement of material throughout fabrication and assemblies, movement of tools, all shop paper and records of work in process, finished parts and assemblies, the operation of all stockrooms and interdepartmental transportation. In other words, all parts are the property and responsibility of the production department, which assigns them for fabrication or assembly to the factory departments, this responsibility being in effect until delivery is made to the customer. This presentation will be primarily concerned with the control of production in the manufacturing departments at Vultee Field.

FORMULATING THE SCHEDULE

A schedule developed to the highest possible degree is most important, not only for the manufacture of parts, but also for the subcontract deliveries, purchased-parts deliveries, and deliveries of those parts to be furnished by the Government in order to meet assembly requirements. One classification is as important as another. Every part must be on hand at the station when the work is to be performed.

The preparation of such a schedule is the responsibility of the production department. The schedule must be broken back from final assembly requirements through major assemblies, accessory assemblies, and subassemblies to the actual parts requirements, taking into consideration time elapsing for labor in the manufacture of the assemblies. Take, for example, a tail-wheel assembly which must be installed in the monocoque line. The major assembly is composed of two Vultee-made subassemblies, one subcontracted assembly, one Government furnished assembly, and four machine-shop parts. Each of the two Vultee-made subassemblies consists of a purchased part and two machine-shop fabrications, together with numerous small parts, such as bushings. The major assembly is manufactured on a daily basis; the subassemblies are manufactured on a weekly basis; while the fabrications for the subassemblies are manufactured on a 4-week-cycle basis; the schedule requirements being computed accordingly. Thus, for each assembly, as for the tail-wheel assembly, is established that date when parts must be on hand, actually available to start the subassembly or accessory assembly, to meet the requirements of the major assembly, which in turn must be complete to meet requisite needs of final assembly, controlling the manufacture of the most insignificant washer to the most complicated part involving perhaps 40 operations.

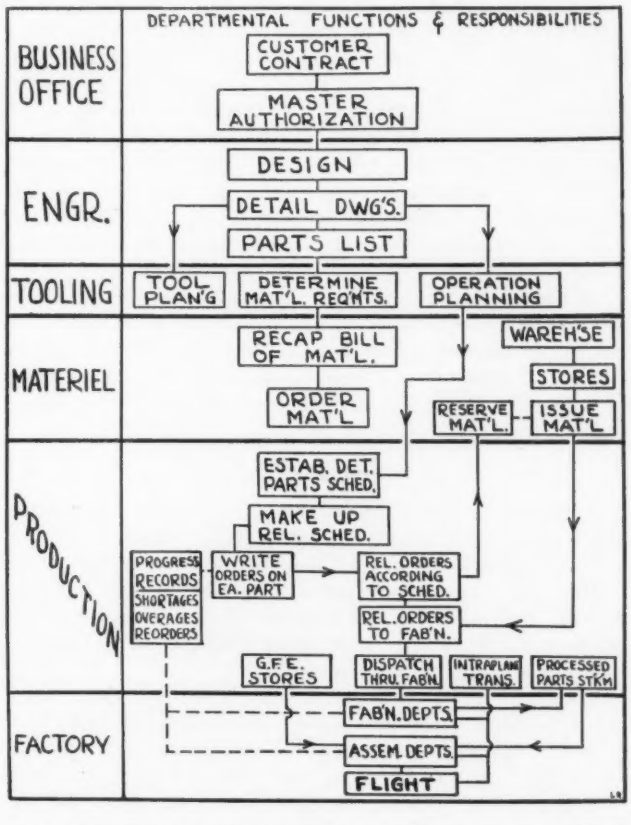

FIG. 1 FUNCTIONAL CHART SHOWING RELATIONSHIP OF PRODUCTION TO OTHER DEPARTMENTS

Contributed by the Management Division and presented at the Semi-Annual Meeting, Los Angeles, Calif., June 14–17, 1943, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

FIG. 2 MASTER SCHEDULE BOARD

An unrelenting follow-up is maintained by means of schedule boards or pin boards installed in each assembly department. These boards comprise a complete list of assembly numbers and parts required for a given period, shown by dividing the board vertically into calendar days, where quantities are posted from inspection reports for that date. A marker moved daily indicates the current date. Red pushpins in proper day columns to the left of the marker show any assembly orders behind schedule requirements. Blue pins to right of the marker show production in advance of schedule. Similar boards, Fig. 2, incorporating the information for all departments, provide an over-all production picture for management, immediately disclosing any unsatisfactory performance. Too many parts as well as too few are considered unsatisfactory. The boards in addition to their informative value are a constant reminder that schedules must be met, because a failure could be ruinous, especially where mechanically moving assembly lines are employed as extensively as they are at the Vultee Field Division.

It should be mentioned at this point that never since the first installation of powered assembly lines, pioneered by Vultee in the aircraft industry over 2 years ago, have these lines been shut down for a single moment due to a part shortage; this in spite of the fact that delivery schedules have been increased monthly.

ORDER RELEASE

Parts requirements dates having been determined, the contract is divided into releases, giving special consideration to the most economical lot size for manufacture to meet schedule requirements. The detail parts schedules, which have been worked out, showing the number of days prior to delivery when each part must be started, are then applied to the release schedule and orders are written.

The shop orders on tabulating cards are reproduced by the ditto process directly from the master planning prepared by the tooling department referred to previously as "operation planning." Shop orders for each detailed part are written and grouped in packets. A packet consists of a "job progress" folder (manila) enclosing a "material reservation" copy (white flimsy), "stores issues" (salmon flimsy), "job assignment cards" (pink), one for each cost center, "traveler" (manila), which during fabrication is detached from the packet and remains with the material, a "setup" card (green) furnished when specially trained personnel or special handling is required, such as installing a complicated jig or die, and the blue or "close-out" card, which, when the packet is released to fabrication, is detached and remains in the office file until parts reach finished stock. At that time, the "traveler" is detached from the material and returned to the office, officially closing the order, where the blue card is cleared from the active file, date stamped, and forwarded to the cost accounting department, the quantity of good parts accepted by the inspection department being posted on the master.

After the orders are written they are checked with material control of the matériel department by the production-control office forwarding the white flimsy and salmon flimsy 30 days in advance of shop requirements. Material is reserved and stamped on flimsies by material control and both flimsies returned to the production control department, where they are filed with the corresponding part orders ready for release to the proper fabricating department for manufacture.

FABRICATION SHOP PAPER

When the shop orders are delivered to the production release booth in the Fabricating Department, the material is known definitely to be on hand. A typical release booth is shown in Fig. 3. On the proper day as shown by the scheduled starting day on the shop order folder, the order is released by the dispatcher at that booth for cutting, the white and salmon flimsy being attached to the traveler, material assigned, first from cull, then raw stock if there is insufficient cull to fill the order. In that way cull is kept to a minimum. When cut from raw stock, standard material-specification cards show exactly how cuts are to be made, thus reducing the amount of cull which could be caused by an inexperienced operator. Upon assignment of stock, the traveler and salmon flimsy are attached to the material, the white flimsy stamped "material O.K." and turned in at the production release booth. The salmon copy is detached after cutting and is returned to the material control department for proper entry on a Kardex stock record. After return of the white flimsy to the release booth until completion as a finished part accepted by the inspection department, the job is in the hands of the dispatch group.

As previously stated, shop orders are dittoed from operation planning masters. Each job-assignment card therefore shows the contract number, part name, part number, material specification, kind of material, size to be cut, operation number, operation description, department number, cost-center number, work-station number where work is to be performed, and the tool number required for each operation. Every work station in the department is numbered to correspond with the station numbers established in the planning.

It is therefore the dispatcher's responsibility (1) to understand the dispatch procedure thoroughly; (2) to know the

location and type of work performed at each work station in his area; (3) to know when to dispatch work and tools to the work stations, and vice versa, to return tools to the crib after completed operations, and to order material from a completed operation to its next operation; (4) to know by record when tools are with the material; (5) to write necessary rework paper to comply with inspection department or salvage board recommendations; (6) to write necessary partial orders if emergency warrants; (7) to write the necessary tool-breakdown report in case a tool fails and to move the material to the hold area until the repair is completed.

FIG. 3 FABRICATION RELEASE BOOTH

COST CENTER DISPATCH

To accomplish dispatching, each fabricating department has booths, one for each cost center, which is a grouping of work stations according to work performed. Each job dispatcher operating a cost-center booth is responsible for the stations and work in his cost-center area and reports to the department dispatcher.

Each booth has its incoming receiving area. Hand truckers, when delivering a job to a cost-center booth, deposit the skid with the material in this area and hand the shop paper to the dispatcher securing his initials on their move ticket, which is their receipt that material was moved correctly and the proper shop paper delivered. The receiving dispatcher may either dispatch the material to a station or, if no space is available, place the material in an accumulation area, Fig. 4. In either case, after making his decision, he writes a move ticket in duplicate, filling in instructions in the spaces provided on the form.

When work, as called for by operation planning, is completed in his area, the dispatcher forwards the material and paper to the next booth and returns to tool crib the tools used on the completed operaton. To accomplish this he writes a move ticket in duplicate, filling in spaces provided on the move-ticket form, which identifies the part, shows material moved from and to, states tool number and location and where it is to be moved, initialing the instructions.

PLANT LAYOUT

Allied with a successful dispatch system, careful consideration of plant layout is essential. The arrangement and placing of machinery, work benches, ovens, and the like, at Vultee Field provides for routing work through the fabricating departments so that it will flow from one work station to another with no backtracking. Every work station has its designating number, whether a machine, furnace, or a bench. Floor space for two jobs at each station has been provided, with provision in the dispatch system always to have a "working" and a "next" job at every station.

As all work in process cannot be stored at a work station, "accumulation areas" for accumulation of material between operations have been provided, Fig. 4. We are convinced that accumulation areas are as much a part of plant layout as machine placement. For control in the fabricating departments, they are vital. Utmost consideration is given to storing materials in close proximity to the machines or work stations where work is to be performed. Each accumulation area is identified by a letter easily seen. The areas are outlined with white lines on the floor and are subdivided into stalls, also marked in white, each stall being identified by a number on the floor. Dispatchers filing in the job folders completed move tickets on which is marked the accumulation area letter and the stall number know exactly where every job is located. One accumulation area centrally located in each department has been established as an "incoming" area, which in reality is a "depot" for deposit of materials or parts involving interdepartmental moves.

The last operation having been performed in fabrication, the parts clear through the inspection department and receive the specified finish. All painting is done by spraying. The parts are spread on trays, suspended from carriers on a mechanically moving conveyer line, travel through the spray booths and drying ovens, and emerge painted and dried. They are then removed from the trays, placed in tote pans or tubs, which are picked up by the intraplant transportation system and delivered to the proper processed-parts stockroom.

INTERDEPARTMENTAL TRANSPORTATION

Intraplant transportation, as well as processed-parts stockrooms, are also vital functions under the jurisdiction of the production control department. The transportation department is charged with the responsibility for movement of all material or parts between departments, the care and operation of all handling equipment, including power trucks, hand trucks, skids, skid bins, stacking pans, caster trucks, flat trucks, and specially built equipment.

Intraplant transportation at Vultee Field operates in a similar manner to a railroad system, or the service of supply for an army. All personnel are given special training until they are familiar with the equipment safety regulations covering intersection stops and speeds which are rigidly enforced. The central dispatch station is the clearing center, where all tow-motors report, receive orders, and are dispatched on their various missions. Regular routes on fixed schedules are laid out for "express service," the materials or parts for interdepartmental moves being concentrated in the department depots,

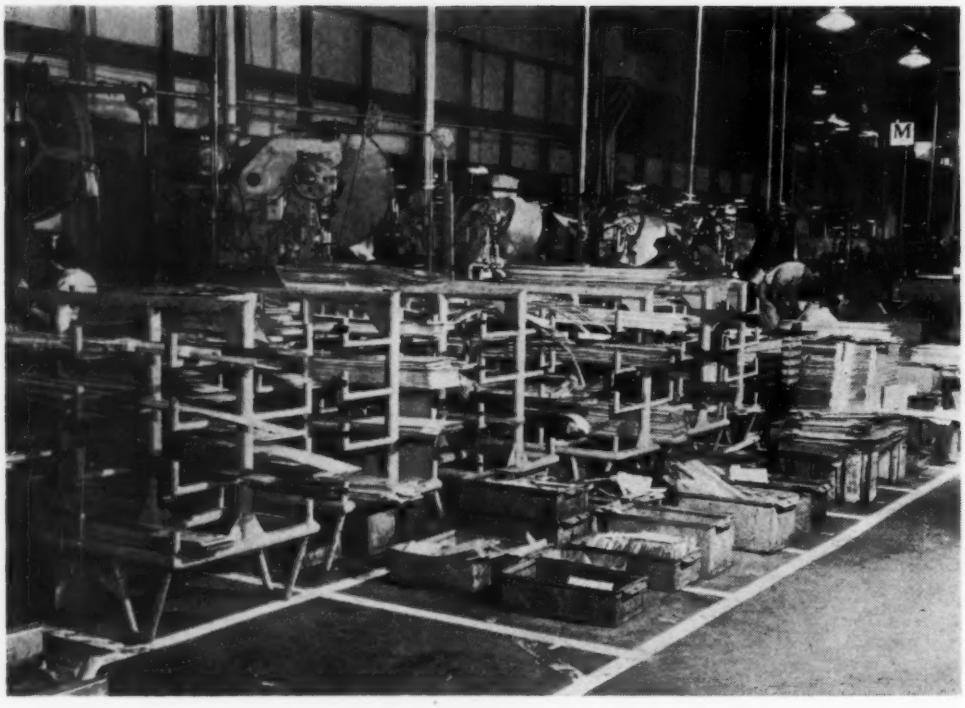

FIG. 4 ACCUMULATION AREA

or "in" and "out" areas, where they are picked up and moved according to planning as shown on the shop paper traveler.

Moves which cannot be hauled by the express service, such as unloading engine crates or changing the 2-ton dies, which are used in the larger presses, are dispatched by individual orders. Intraplant is also held responsible for the movement of parts from raw stock or finished stock to the various assembly departments throughout the division.

ASSEMBLIES DEPARTMENTALIZED WITH COST-CENTER CONTROL

The assembly departments by careful engineering analysis have been allocated floor space necessary to build the particular assemblies assigned them for manufacture. Assemblies are divided into four main divisions, namely, subassemblies, accessory assemblies, major assemblies, and final assembly. Each assembly department is arranged with separate cost centers. In the case of subassemblies and accessory assemblies, these cost centers consist of production lines which have been set up after analysis of the operations on similar parts. The analysis indicates what groups of assemblies follow the same general sequence. Machines, benches, and equipment are then set up to follow this sequence. The parts to be assembled are issued by the process parts stores, transported by intraplant transportation to the proper department, and move forward from one assembly operation to another either on conveyers or specially designed handling equipment, until they emerge completed.

As the finished assemblies come off the end of the line, they

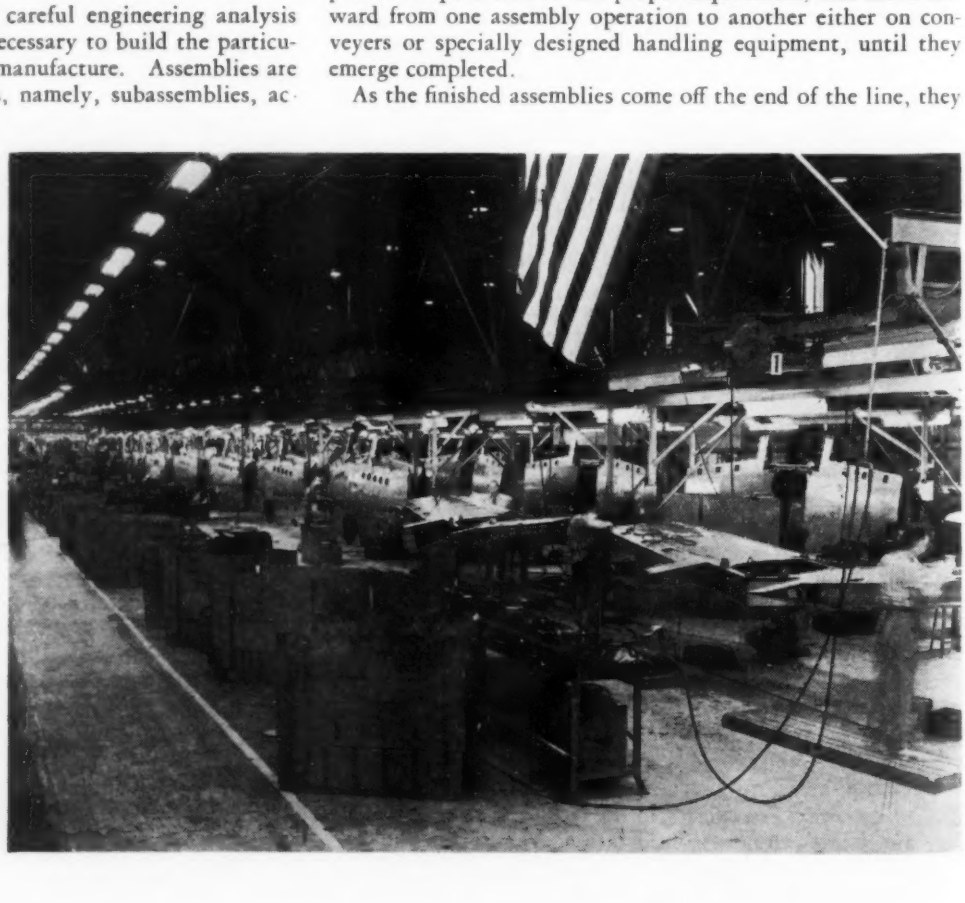

FIG. 5 CENTER SECTION CONVEYER ASSEMBLY LINE

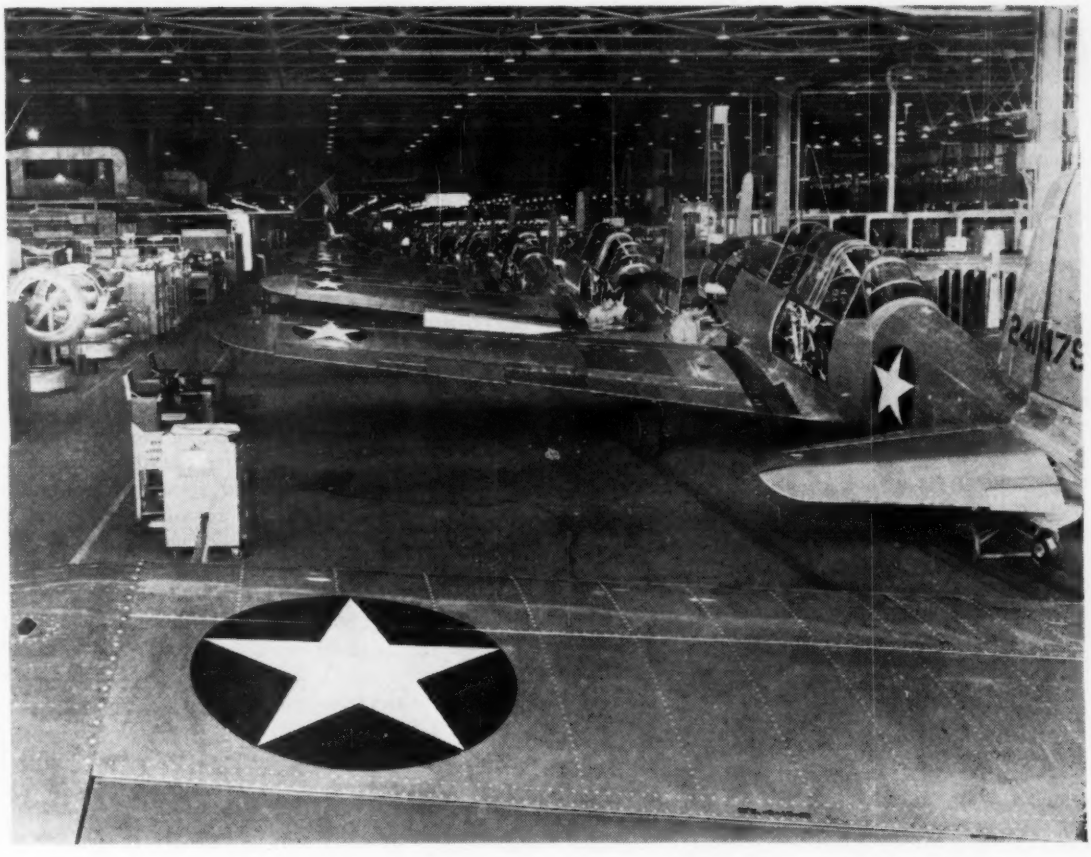

FIG. 6 FINAL MECHANICAL CONVEYER

pass through an inspection station. The cost center is used for accounting as well as production-control purposes, and the actual time is compared with standards to insure steady uninterrupted production flow.

In major and final assembly departments, each major assembly jig or production line is set up as a cost center and provision made for recording production and measuring against standards similar to the subassembly lines.

The operations-planning section provides a bill of material for approximately 1 week's production, specifying the quantity of each part required at each station, one copy of which goes to the stockrooms as authority for scheduled issue. All material is delivered to its proper cost center when called out by the production dispatcher who is responsible for having it where it will be used when required. Standard timing has been established to indicate the amount of time allotted to complete each assembly. Based upon these standards, the number of personnel in each cost center has been definitely assigned. To insure quality of workmanship, work in operation centers and in all complete assemblies must be accepted by the inspector before it can proceed to the next operation center or assembly.

MAJOR ASSEMBLIES OF THE AIRPLANE

The major assemblies of the airplane consist of the following steps:

1 Center-section assembly: The main section of the wing structure.

2 Outer-wing assembly: The balance of wing structure on right and left side of ship.

3 Monocoque, vertical and horizontal stabilizer assembly: The entire tail section of the ship or empennage.

4 Fuselage assembly: The body of the ship or cabin space for pilots and their instruments.

5 Accessory assemblies: Engine, propeller, radio, generator, all electrical panels, boxes, and tubing.

6 Final assembly: The final group of operation centers to assemble all major assemblies.

An illustration of the construction of the center section will show the flow from subassemblies to the final assembly. The main beam and nose section are built in subassemblies and then are combined into one major assembly. Simultaneously, paralleling this operation, the outer and inner panel sections which contain the gas tanks are constructed. At a further point down the line, the rear spar section is placed on these outer and inner panel sections, which produces the intermediate panel section. Two of these intermediate panel sections are joined with the main beam and nose assembly in a master assembly jig from which they are removed by one man operating a specially designed transfer hoist and start down the center section conveyer assembly line, Fig. 5. Here all assembly operations are balanced into equal time cycles with a crew at each station performing certain regular items of work arranged in progressive sequence. After all the operations are finished along the major assembly line, the center section, suspended by the jig serving as a carrier, travels on the conveyer through the paint shop and to the final assembly line, Fig. 6.

The same progressive system of assembly visualized by the flow of the center section is also used on the outer wing assembly, monocoque, vertical and horizontal stabilizer assembly, fuselage assembly, and accessory assemblies, which includes engine assembly. All are mated in final assembly where monocoque meets fuselage which in turn meets center section, and later the power plant forming the completed airplane as assembly progresses down the precisely moving mechanized conveyer ine, to be towed onto the field, serviced, tested, and flown away.

Modern METHODS *in* AIRCRAFT WELDING

By NAIRNE F. WARD

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THE first stage in the manufacture of aircraft required little or no welding since fabrication largely involved the use of wood, fabrics, and wire. Early manufacturing methods were simple, and their use was confined to such places as barns and back rooms of establishments producing other articles of commerce. This was the crude origin of the modern streamlined aircraft plant. As the industry grew rapidly during the first world war, the use of welding was required for a greater number of parts. In the period of the early twenties, welding with its ability to combine maximum strength with minimum weight contributed the all-welded fuselage. During the late twenties and the early thirties, the demands for transport planes for extending the transcontinental air routes placed more emphasis on the speed of production. Welding was one of the processes which aided in building heavier airplanes faster. The techniques of manufacture were vastly improved but were still far from the days of mass production, which lay ahead.

The need for a greater volume of aircraft demanded more efficient methods in the late thirties. The arrival of demands for five-figure output in the early forties necessitated a tremendous volume of welded parts. When we hear of the still larger airplanes in prospect, we know that this challenge will have to be met by providing efficient, timely, and accurate methods of fabrication. With such a broad background of usefulness as that represented by the welding processes, an outline of present-day applications will serve to fix the place of welding in the battle of production.

All welding processes used in aircraft production may be classified as fusion welding or pressure welding with their subdivisions, as shown in Fig. 1.

Fusion welding includes all the processes in which the

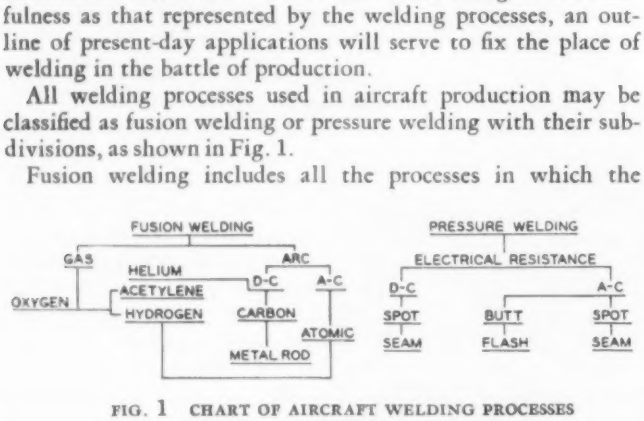

FIG. 1 CHART OF AIRCRAFT WELDING PROCESSES

natural forces are used to join preheated metal without additional external pressure. Fusion-welding methods used in the aircraft industry comprise gas and arc welding, with some use being made of the atomic-hydrogen-arc and helium-arc processes.

Pressure welding includes the processes in which the metal to be welded is subjected to external pressure during the welding operation. The electrical-resistance methods of spot, seam, and flash welding are the most extensively used pressure-welding processes in aircraft manufacture. In general, the aircraft industry has made use of such welding processes as meet its needs.

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FUSION WELDING

Scope of Gas and Arc Welding. The amount and intensity of the heat liberated by each welding process determine largely the methods which are used in adjusting the effects of this welding heat to the final structure. Often the importance of the change in physical properties of welded metals is a deciding factor.

Established procedures for use of the fusion-welding processes in aircraft manufacture are well understood since these principles have been practiced in the production departments since the early twenties. The only reason for treating the subject here is to recall the importance of this control of the welding process in its modern role of facilitating production. The performance of aircraft parts has been made satisfactory by the use of the principles of procedure control. A brief outline will serve to establish the basis upon which procedure control functions for the aircraft industries as well as other allied industries.

Procedure control may be outlined in the following terms:

1 Design for welding.
2 Inspection of material prior to welding.
3 Establishment of shop procedures, including material preparation, and welding sequence to be used.
4 Certification of welding operators according to Federal requirements.
5 Testing and inspection of assemblies.

Design for Welding. Only designs which permit maximum accessibility for the gas flame or arc are considered satisfactory, because they permit the time of welding to be reduced and the warpage due to welding heat to be held to a minimum.

Inspection of Materials. Tube and sheet stock should be inspected for seams or other defects which experience has proved to be detrimental to sound welded structures. Magnaflux inspection of welded-steel assemblies should be made prior to expensive machining operations. In general, control exercised at this stage is good insurance against defective products.

Preparation of Material. The most important item, for an efficient and rapid production of welded parts in quantity, is preparation of the mating edges of sheets and the shapes of tube ends. Mass production of a large number of identical parts justifies the use of machine methods for this tube and sheet preparation. Examples of speedy and economical methods used in this preparation are the cutting of scarf ends with a power saw or cutoff grinding wheel and the nibbling or milling of tube ends to fit in cluster joints.

To complete the production cycle, all duplicate parts are placed in a portable bin for the welding operator to draw from when needed and slip into the assembly jig with minimum delay. The principle of moving work to the welder in classified bins gets the welding done more quickly.

Jigs. Modern jigs are more than frameworks in which the parts are held with respect to one another. They provide quick clamping of component parts and least dissipation of heat away from the weld. The operator is required to devote

only a minimum amount of attention to the preparation of parts, leaving the maximum time for his job of welding. Movement of the operator is greatly reduced, for the jigs are made to tilt or rotate, permitting down-hand welding to as great an extent as possible. Through accessibility in jigs, the maximum encouragement is given the operator to do the job accurately, efficiently, and economically.

Weld Procedure. Any thought that the jig may be a cure-all for all "reworks," is premature, for expansion and contraction follow along with the weld. Distortion due to variation in the application of heat is difficult to control with slipshod methods. Distortion can be controlled when the direction and amount of welding are prescribed for each welded part in advance. Aircraft welding procedures now provide such information in the form of operation instructions for a large number of parts and assemblies. By means of this procedure and the use of jigs, it is not difficult to explain the fact that slight variation is found in the welded product.

Certification of Welding Operators. Tests required by the U.S.A.A.F. Specification 20013-C form the basis of judging welding operators, and the quality of welding they perform. Successful completion of tests entitles welding operators to receive Class "A" rating which permits their welding on any part of an airplane. Others may be allowed to weld nonstructural parts only. These tests do not constitute approval of the process, rather they serve to indicate the ability of the personnel to do a certain kind of welding, or they may serve as an indication of the type of personnel in any plant which is capable of doing the kind of welding required.

Testing and Inspection. This procedure includes checking of the assembly for compliance with design and procedure requirements. Completed welds must be subjected to tests to determine the absence of weld defects. Two types of tests commonly used are air tests and magnaflux for steel welds. These tests are well known and need no description here.

ELECTRICAL-RESISTANCE WELDING

The use of electrical-resistance welding, long an important method of fabricating steel, has been extended to include aluminum, aluminum alloys, and magnesium. Seam welding, although noted as a separate process, is actually an extension of the spot-welding process. Through the use of resistance welding, aircraft products have been improved, cost of fabrication reduced, and production increased. Resistance-welding equipment is subject to certification by Federal agencies.

Certification of Spot-Weld Machine and Operator. The procedure for the use of the spot-weld method for the fabrication of aircraft parts has been established by agencies of the Federal Government. The method by which approval of the spot-weld machine and operator is obtained will be briefly outlined.

Spot-weld consistency tests which are necessary in certification of approval of the machine and operators are obtained by the liaison engineer of the aircraft company and forwarded to the customer. By means of these tests, approval of spot- and seam-welding machines and operators is obtained.

Specifically, these requirements have been made for 24S-T Alclad aluminum. Similar procedures may be required for stainless steel, magnesium, and other aluminum alloys which are to be spot-welded.

The certification of spot- and seam-welding machines includes submittal of 20 single-spot specimens in each of the following combinations of 24S-T Alclad aluminum used in production: (*a*) Minimum gage, (*b*) in-between gage, (*c*) minimum to maximum gages, (*d*) maximum gage.

All test specimens are cleaned prior to spot welding under the same condition as used in production.

Findings of the following laboratory tests on single-spot test specimens are made the basis of machine certifications:

1 Shear tests of ten of the twenty single-spot specimens.
2 X-ray examinations of ten of the twenty specimens.
3 Microscopic examinations of five of ten specimens in (2).

Certification of the operating personnel is accomplished by having the operator make single-spot samples of the various gage combinations for which the spot-weld machine was certified. Operating personnel are required to determine the correct machine settings to be used during this test.

The judgment of the quality of the spot welds, which are produced for the purpose of certifying machines and operators, is made by certified testing agencies outside the jurisdiction of the aircraft plant. With these data as a basis, final approval for operation of spot- and seam-welding equipment remains a function of the procuring agency.

Materials for Spot Welding: The spot-weld method of assembly is applied to various combinations of the materials suitable for spot welding. The metals of like and unlike composition are summarized in Fig. 2. The combinations noted in

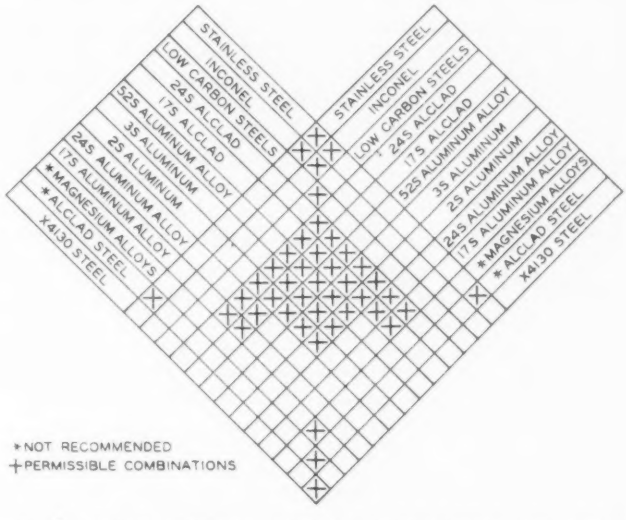


FIG. 2 CHART SHOWING TYPICAL COMBINATIONS OF METALS APPLICABLE TO RESISTANCE WELDING

Fig. 2 do not exhaust the possibilities of the spot-weld method; rather, they are the combinations being used in present practice.

Surface Preparation. Several cleaning methods are in use for preparation of the surfaces of sheets or parts for spot and seam welding. The purpose has been to supply material with relatively constant surface resistance for all parts thus treated.

Methods of surface preparation for steel, aluminum, or magnesium vary among the different aircraft plants. For steel parts, degreasing remains the principal means of preparation. The parts must be degreased just prior to the spot-weld operation. For steel parts, coated with scale and grease, steel-grit blasting is satisfactory and may be done well ahead of the resistance-welding operation. The parts are then stored in a dry place where there will be little possibility of corrosion.

Aluminum alloys are cleaned in suitable solvents. The parts are then etched or deoxidized prior to spot welding. The use of stainless-steel wire brushing to prepare the surface for spot welding is common practice, although care must be exercised to prevent the wire brush from cutting through the pure aluminum coating on certain aluminum alloys, thereby destroying the corrosion resistance of the aluminum-clad surface.

The production scheduling of aluminum parts for spot-weld operations depends upon the methods of surface preparation used. For example, where the wet-etching method is used on

assemblies of several components, handling all of the components at one etching is desirable. Since the duration of the deoxidizing effect of most etching solutions is 48 hr, the spot or seam welding of all components should be completed within that time after etching. Otherwise, standard machine settings must be changed to meet new and varied surface conditions.

Electrode Tips. In spot welding, after the material has been properly located by the operator, the operations are: Applying electrode tips to the work; passing current through the electrode into the work; and withdrawing the electrode from the finished spot weld. These operations are all performed once the foot switch on the modern spot-weld machine is depressed. The use of a minimum number of separate types of electrode tips has proved to be a time saver and a means of reducing inventory costs drastically.

Extension of the service life of electrode tips has been made possible by the following methods:

1 Tips should be cooled to an average temperature of 45 F or less the year round, because lowering the temperature of the tip reduces the frequency of tip cleaning. Actual studies show that tip cleaning need not exceed 0.22 per cent of the weld time or 8 sec per hr of spot-weld time. Weld time is used as a basis of comparative studies for it is the productive time necessary to make the spot-welded parts.

2 When tips are operated at lower than room temperatures, the dimension *A* in Fig. 3 may be made greater and still produce the same cooling effect. This allows a greater depth of working surface to be used before the electrode need be discarded, since rejection of tips usually occurs when the dimension *A* is less than $^1/_8$ in.

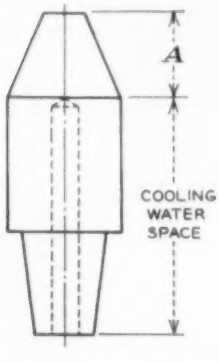


FIG. 3 ONE STYLE OF ELECTRODE TIP

3 Much valuable electrode material can be saved by having worn tips refinished to original contour by trained personnel.

Jig Practice. Jigs and fixtures which properly locate component parts are used wherever possible. Jigs should be designed to serve a dual purpose:

1 The jig can be used to check the fit and contour of parts.

2 The parts are held in proper relationship until tack welds have been completed.

The jig, shown in Fig. 4, serves as a checking fixture before spot-welding. When parts are placed in this jig, relative coordination may be seen. The tack welds are located by the cutout areas. Reduction in weld time is obtained with minimum warpage because of this preliminary tack-welding operation. The part is then removed from the jig and completed at the spot-weld machine. With proper spot-weld sequence, warpage is held within allowable limits. The effect of weld sequence is discussed later under "job analysis."

Tack Welding. A method of preassembly of component parts in jigs, known as tack welding, is applied to steel and aluminum parts. The principal purpose in tacking parts is to reduce the down time due to jig handling at the large spot-weld machines. While not a new feature of production-line operations, tack welding with portable welding guns is faster and more flexible than tack welding with the stationary spot-weld machine. By the use of this method, the jigs are removed before the finish welds are completed on the large spot-weld machine.

For seam-welded parts, tack welding is indispensable in order to clear seams of unnecessary obstructions such as fasteners, before placing the components on the seam welder.

Tack welds are not expected to qualify as structural welds, so machine welds must be placed on either side of each tack weld.

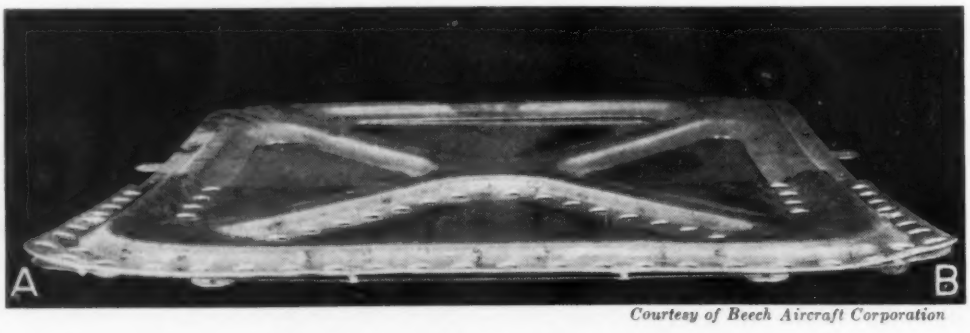
Job Analysis. The rapid heating and cooling during the spot-weld operation produces warpage in sheets. In extended seam lengths, the sheet stock "lifts" or "sinks" away from the desired contour, depending largely upon the following factors:

1 The machine settings.
2 The relative tip diameters.
3 The difference in tip contours used, spherical against flat tips, etc.

Prevention of uncontrolled sheet distortion and production of uniform parts have been achieved by breaking down the spot-welding sequence and making a suitable record of each operation. A job-analysis card, a sample of which is shown in Fig. 5, should be worked out by the spot-weld engineer in co-operation with the spot-welding department. Such job-analysis data should be available as a guide to each welding operator in enabling him to complete each job successfully in the minimum time, without rework being required. By the use of this type of guide, very little is left to the judgment of the operator. Experience suggests that the loss due to reworking of salvaged parts can be reduced when the operations-analysis card is used.

Inspection. All spot-welding inspection is usually placed under the jurisdiction of the inspection department. The spot-welding inspection staff should be trained in the requirements of the spot-weld method. The most important items checked by the inspection staff are as follows:

1 Preparation of Parts. All parts to be spot-welded should be inspected after cleaning and before spot-welding to insure freedom from oxide coatings.



Courtesy of Beech Aircraft Corporation

FIG. 4 SPOT-WELD JIG FOR DOOR ASSEMBLY

[A-B held to jig contour by quick clamps (not shown). Locator pins on jig shown in Dzus holes. Spot welds in order of job analysis, Fig. 5.]

PART NO. NAME: DOOR ASSEMBLY
JIG NO. REQUIRED: 505-506750

JIG REQ'D	MATERIALS	SPOT SPACING	NUMBER OF SPOTS	ELECTRODES			
				TOP	SIZE	BOTTOM	SIZE
YES	.016 -17ST ALC .025 -17ST ALC	3/4" APPROX	4 2 0	60°dome	5/32"	FLAT	3/8" vs OUTER SKIN

MACHINE SETTINGS

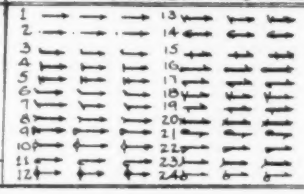
MACH TYPE	CAPACITOR		PRESS	VOLTS	CHARGE	TURNS RATIO	TIME sec.	
	Coarse	Fine					Hold	Off
Condenser Discharge	1	3	680	± 5% 2280	High	300/1	.05	.075

Electro-Magnetic Discharge	Resist Blocks	PRESS	AMPS.	RE COMP	DELAY	RPEPEAT	POLES
	5 & 6	30-36	± 5% 140	Yes	4	12	8

A. C.	TAP	HEAT CONTROL	PRESS	WELD	FORGE TIME	REPEAT
100 KVA	2 -Par.	45	650	3	8	5

COURTESY BEECH AIRCRAFT CORPORATION

OPERATIONS SEQUENCE:



OPERATIONS BREAKDOWN

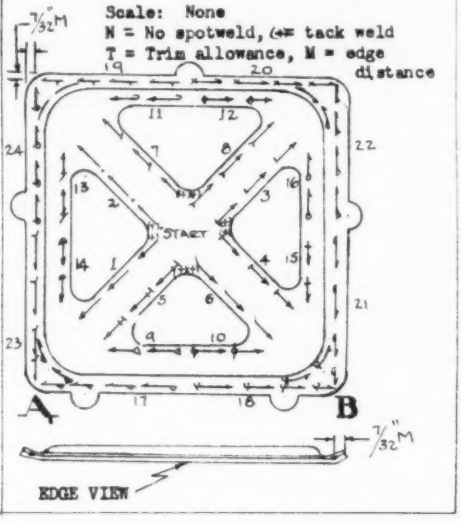
SHOP ORDER	IN SPOTWELD DEPARTMENT	SET-UP SKETCH
1. Assem after etch 2. Drill 3. Assem 4. Spotweld - Spec A.C. 20011-B Note:1. Check age of etch. If over 48 hrs. old use stainless steel wire brush on faying surfaces. 2. Report mis-match of two skins to crew chief before starting to spotweld. 3. Welds called out on print but not shown may be run from center of areas outward to the edges.	General: Hold work squarely up to electrode tips. Button size 3/32" minimum 1. Make tack welds (+) at center and at holes in jig. 2. Remove jig. 3. Run spotwelds in operations 1 - 16 being guided by top side or stiffener flanges. 4. Complete welds on all edges in operations 17-24.	

FIG. 5 SAMPLE SPOT-WELD JOB-ANALYSIS CARD

2 Fit of Parts. Parts to be spot-welded should be inspected for fit to see that only a small portion of the electrode pressure need be exerted to bring maladjusted parts into contact before application of the welded current.

3 Machine Settings. When each new setup is made, the inspection department should be privileged to check the machine settings as specified on the job-analysis card and the electrodes should be checked for perfect alignment. No deviations in setting over ± 5 per cent of the established machine settings should be allowed.

4 Spot Shear Test. When new settings on machines are made to suit different gages, shear-test specimens are prepared and tested. All specimens should meet the minimum load specified in Table 2 of Army Air Forces Specification 20011-B. These specimens shall duplicate the production job in gage, metal, and finish.

Production should cease immediately upon detection of cracked or excessively burned spots usually caused by electrode pickup.

5 Finished Parts. The values of spot spacing, pattern, and edge margin should be checked periodically for agreement with specific drawing requirements. The first part may be submitted to inspection to determine compliance with these requirements. Frequent check with shear-pull specimens is one detail for the inspection department to supervise for control of spot-weld quality.

Maintenance of Equipment. The following outline indicates a procedure which will assure the best operating conditions and provide uninterrupted operation of spot-weld equipment:

1 Tip Maintenance. Welding tips or electrodes, constituting the vital link between the power and the finished weld, must be provided in sufficient number. The importance of electrode condition in the determination of the spot-welding results cannot be too strongly emphasized. For this reason the following suggestions are made:

(*a*) All types of standard electrodes should be stocked at each machine in sufficient quantities to provide for continuous operation.

(*b*) A supply of fine abrasive cloth should be furnished at each machine for quick removal of tip "pickup" whenever the spot-weld surface indicates the necessity.

(*c*) Refacing tools should be made available to dress the tip faces whenever required and should be kept in serviceable condition.

SPOT WELD MACHINE MAINTENANCE LOG
(Attach to Machine)
MACHINE NO. _____

Note to Maintenance Crew:- All trouble shooting is entered on this record for each call to this machine.
Signed: Plant Engineering Authority

Date and Initial	Reported Condition	List of Repairs and Replacements
8/5 - A	Press head sticks.	Broken lead to CR1 soldered
8/5 - A	Voltage varying	Cleaned relays at contact points
8/16 - A	R-Relay fails to operate due to auxiliary contact on F-Relay	New frame for F contactor installed
8/17 - A	Fuse blown on fan.	Fuse replaced
8/19 - A	Two fuses out on fan.	Dust cleaned from motor Fuses replaced
8/24 - A	Press head holds down without firing	Air pressure below micro-pressure switch setting.
9/1 - A	Voltmeter fails to read.	Replaced armature contact on voltage relay.
9/4 - A	Does not fire	Contact on F relay replaced.

Entries on this log are given to show the type of trouble experienced with one spot weld machine. Proper entries serve as a guide for planning equipment replacement and servicing periods.

FIG. 6 TYPICAL SPOT-WELDING MACHINE-MAINTENANCE LOG

(*d*) Tip contours should be remachined in a lathe whenever necessary.

(*e*) Wrenches for extracting tips should be made available at each machine.

2 Machine Maintenance. The mechanical and electrical operation of machines should be checked periodically according to the following requirements:

(*a*) Pressure. Check with electrode pressure gage for correct electrode pressure.

(*b*) Current. All current-regulating and controlling devices should be checked. The machine should be checked for burned relay contacts, loose connections, and faulty operation.

(*c*) Voltage. Voltmeter calibration should be checked with an accurately calibrated voltmeter. All contacts for voltage taps, and all capacitor, inductor, and selector connections should be kept clean and tight.

(*d*) Time. All timing and sequence controls and relays should be checked carefully and kept in electrically and mechanically sound condition. Periodic cleaning of electrical contact surfaces in relays is important in keeping the elements timed.

(*e*) Cooling. All parts of the electrode-cooling system should be checked frequently for proper functioning and kept in good repair to insure adequate, trouble-free cooling of electrodes and transformers.

(*f*) Mechanical Parts. Lubrication of all moving parts in proper amounts for continuous operation should be attended to at intervals. Any electrode bracing must be tightened before spot welding.

(*g*) Records. An accurate record of service required by each machine will prove beneficial in that future service requirements may be accurately predicted on the basis of past service. A convenient way to compile this information is in the form of a maintenance log. A typical log is shown in Fig. 6.

With proper maintenance, the settings on the job-analysis cards, Fig. 5, will be of maximum value, since these settings are based upon optimum machine performance.

Flash Welding. Flash welding has been found to have sufficient production advantage for acceptance by the industry in fabricating a wide variety of parts. Principally, steel parts have been flash welded, although some nonstructural aluminum-alloy parts have been welded by this method.

Butt welds on steel tubes and rods are readily made by flash welding. Joints made as shown in Fig. 7 (*a*, *b*, *c*, or *d*), may be welded satisfactorily, but joints of the type shown in Fig. 7(*e*) will not be, because the edges under little or no pressure are burned off unevenly, thus destroying the continuity of the weld.

Parts are machined to insure even fit-up of mating tubes, forging, or rod ends. Flush ends machined thus can then be loaded in the flash welder and clamped by dies (electrodes) on opposite sides of the areas to be welded. As parts are moved together, back-up fittings prevent slippage of work, thus requiring less electrode length for clamping the parts. The use of jigs, which are necessary in gas, arc, and spot welding for location purposes, is eliminated since the flash-welding machine carries the dies for rod and tube welding. Dies for other requirements are made to particular designs. Removal of the attending fin or flash may be required, but when the flash has been removed, the pull strength on the joint does not suffer any serious reduction.

Of particular interest in this battle of production is the speed at which the flash welder operates. An average of 200 to 250 welds can be made per hour. On a duty cycle of 50 per cent 6000 sound welds are being made daily on a flash-welding machine, reducing the cost of welding to 25 per cent of the former arc-welding method.

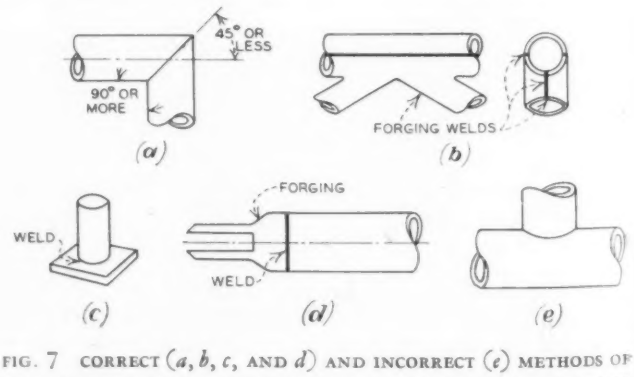


FIG. 7 CORRECT (*a*, *b*, *c*, AND *d*) AND INCORRECT (*e*) METHODS OF MAKING BUTT WELDS ON STEEL TUBES AND RODS BY FLASHWELDING

RESIN IMPREGNATION *of* WOOD

By RALPH CASSELMAN

DEVELOPMENT DIVISION, BAKELITE CORPORATION, BLOOMFIELD, N.

THE story of resin impregnation is part of a larger story, that of the struggle to use to better advantage one of our most abundant and versatile raw materials, namely, wood.

Not many years ago wood technologists and chemists were strangers in most plants, not understood in others, and frequently resented by the production-minded men whose only interest lay in making more of their standard type of production with faster equipment, or cutting the corners further to lower the cost per unit.

These days, however, the story is far different. So many upheavals have taken or are taking place in the wood industries that the total amounts to a mass movement having the momentum of a landslide. Of the many phases of this movement, one of the most important has comprised the association of wood with synthetic resins. We think there is no question but that these resins have in many ways contributed greatly to the renaissance and the present recognition of wood as a modern material of many uses and a future material of many more. Resin adhesives for plywood and synthetic-resin coatings are the two outstanding contributions; resin impregnation may be another.

By impregnation with synthetic resins, we strive to overcome certain of the limitations of natural wood or to develop properties so different as to be considered new. The actual process of impregnation has been so frequently described that we need only outline the procedures in defining the two principal types of treated wood, i.e., impreg and compreg.

PRINCIPAL TYPES OF TREATED WOOD

Impreg is made by impregnating wood, usually veneers, with a synthetic-resin solution, drying, and then baking at 200 to 250 F to set the resin. The treated veneers are usually bonded as with plywood or laminated wood. Impreg has a density fairly close to that of the original wood.

Compreg is made by impregnating, drying, then densifying under heat and pressure with steam platens; pressures run from 900 to 2800 psi; temperature, 260 to 320 F; and press times, 20 to 100 min. Nominally anything compressed to appreciably less than its original thickness has been "compregnated," but the product of greatest current interest has a specific gravity of 1.3 to 1.4, which is fairly close to the maximum obtainable with wood and resin.

When the density is increased in going from impreg to compreg, the mechanical properties change about in proportion. A good tabulation[1] of these properties is given for Jabroc laminated-densified wood made in England (Table 1).

TABLE 1 PROPERTIES OF "COMPREGNATED" WOOD

Specific gravity	Tensile strength, psi	Compressive strength, psi	Modulus of elasticity $E + 10^6$	Shear perpendicular to grain
0.8	20000	...	....	....
0.9	23000	14500	2.8	4700
1.0	25000	16500	3.1	5250
1.1	28000	18000	3.35	5750
1.2	30000	19500	3.5	6300
1.3	32000	21000	3.7	6800
1.4	34000	22500	3.85	7350

[1] These data have been taken from the article, "Resin Laminated Densified Wood," by A. E. L. Jervis, *Plastics*, March, 1943.

Contributed by the Wood Industries Division and presented at the Spring Meeting, Davenport, Iowa, April 26–28, 1943, of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS.

Other types of densified wood are manufactured; one for instance being made by bonding veneers with phenol-resin film under high pressure virtually without impregnation, another by bonding with thermoplastic resins and compressing both vertically and sideways, but in either case no real impregnation takes place.

EFFECT OF RESIN ON PROPERTIES OF WOOD

In both compreg and impreg, wood is the backbone of the products; wood does the work. But the synthetic resin is a valuable accessory and helps to improve the qualities or working properties in which the wood by itself is deficient. A brief résumé of what the resin does for the wood follows:

1 It plasticizes or softens the wood so that it can be compressed to high densities with reasonable pressure, and low moisture content. The effect is illustrated by the pressing of two panels of oven-dried birch of 16 plies of $^1/_{20}$ in., total 0.90 in. After pressing at 1000 psi, the untreated panel remained at 0.79 in. thickness, density 0.76. The resin-impregnated veneers, however, compressed to 0.52 in. with a density of 1.34.

2 The resin holds the plies of veneers together. Since it has been found advisable to treat the wood in the form of veneers, a good durable adhesive is necessary to avoid delaminations.

Sometimes the impregnating resin serves as the adhesive in addition to its other functions, in other cases a separate coating of special adhesive is applied to the veneers to obtain adequate bonding. And in some kinds of compreg, the resin is primarily the adhesive and impregnates only slightly.

In principle, we are inclined to favor the separate adhesive in addition to the impregnant since the full bond is vitally important to the performance of the section, and the added operation is probably worth the insurance. A heavy section such as a propeller may include more than a hundred glue lines of which one failing may ruin the blade.

3 The resin bonds the fibers, fixing them in their compressed state and holding them firmly in place, fortifying them against a tendency to spring back on release of platen pressure or when subjected to the action of moisture. At first glance, this bonding effect might be expected to result in higher cross-grain tensile strength and shear parallel to the grain, but the data are disappointing in that the values run only about in proportion to the density.

4 The presence of the resin interferes with the rate of moisture absorption and penetration. The effect is probably due to several factors, e.g., resin closes the open paths or channels through which moisture might pass; it may react with the wood constituents to produce a material less permeable to moisture. Densification also tends to reduce permeability.

The effect of the resin in reducing penetration even in non-densified wood is surprisingly great especially when it is considered that a continuous film is not observable. Stamm and Seborg reported, treatment with 20 per cent water-solution resin reduced moisture-vapor transmission 90 per cent, compared to an untreated panel, which is better than most coatings.

5 The resin should have a real effect on the ultimate properties of the wood. Note that, in this respect, certain phenol resins at least differ markedly from waxes, oils, natural resins, urea resins, and other impregnants, which only retard the rate of moisture absorption.

These special phenol resins are capable of stabilizing the dimensions of wood so that swelling, shrinking, and checking

are materially reduced. This ability to stabilize is called the antishrink efficiency and can easily reach 65 per cent with one treatment, or 90 per cent with several treatments. For a simple example, wood having a wet or green width of 11 in. and a dry width of 10 in. could by resin treatment be stabilized at 10.65 in. dry, and 11 in. wet. The resin can be an important factor where dimensions should be held closely throughout varying conditions of humidity.

The stabilizing phenol resins also displace the equilibrium moisture content at given relative humidities. Our data show that birch having an equilibrium moisture content of 8 per cent will carry only about 4 per cent when treated with 30 per cent of proper stabilizing resin.

This effect may be of some benefit in minimizing weight changes with increased humidity but unfortunately the control is gained only at the expense of an original weight penalty of about 20 per cent. The weight penalty is not equal to the total resin content, since the volume is increased about 10 per cent by the treatment.

A further and importantly beneficial effect of the stability treatment is the better maintenance of mechanical properties when the wood is wet or higher in moisture content. The natural wood loses strength rapidly with increase in moisture; birch, for example, with a nominal compressive strength of 12,800 psi at 3 per cent moisture content drops to one half or 6400 psi at 16 per cent moisture content.

TABLE 2 PROPERTIES OF RESIN-IMPREGNATED PLYWOOD, NOT DENSIFIED, BONDED WITH BAKELITE RESIN

	Construction	Dry flexural strength, psi	Wet flexural strength, psi
1	3-ply $^1/_{10}$-in. fir, alternate cross-grain, all plies untreated	8600	4320
2	5-ply $^1/_{10}$-in. fir, alternate cross-grain, all plies contain 25 per cent BR-16442 precured	9000	6630
3	5-ply poplar, $^1/_{20}$-in. faces, $^1/_8$-in. core and cross-band, all untreated	....	3940
4	5-ply poplar, $^1/_{20}$-in. faces, $^1/_8$-in. core and cross-band, faces contain 35 per cent BR-16442 precured	....	4820

NOTE: Wet strength taken on $^1/_2$-in. × $^1/_2$-in. × 9-in. samples boiled 10 min, soaked $^1/_2$ hr in cold water.

6 The resin increases the hardness of the wood and to some extent the compressive strength.

7 Usually the impregnation tends to embrittle the wood, in extreme cases causing a loss of 90 per cent of notched Izod value. In a general way, the more thorough the impregnation, the greater the effect on the impact resistance.

8 The impregnating resins markedly improve the resistance of the wood to decay and attack by termites.

9 The phenol resins, at least, increase the resistance of the wood to acids.

PHENOL RESINS AS IMPREGNANTS

A number of synthetic resins have been proposed as impregnants for wood but to date phenol resins have apparently not been equaled on an over-all basis. Exceptions should be noted, including melamine and polyvinyl butyral for certain special applications, but by far the greater bulk of compreg and impreg is made with phenol resins.

In the phenol resins alone, however, there are many variations recommended for wood impregnation, ranging from the low-molecular-weight, water-soluble, extremely penetrating resin on one hand to the heavily bodied, almost nonpenetrating, bonding resins on the other. A distinction is frequently made between the so-called "alcohol-soluble" and "water-soluble," but this distinction is unfortunately not accurate. The water solubles are also alcohol-soluble and the alcohol solubles can be rendered water-soluble. Also some water-soluble resins impart to the compreg the properties usually associated with the spirit-soluble resins. A better distinction might be to call them low- or medium-molecular-weight resins, the low range being 150–200, the medium range 500–1000.

Examples of the way in which the phenol resins do their job are shown by the data presented in Table 3.

TABLE 3 PROPERTIES OF WOOD IMPREGNATED WITH VARIOUS PHENOL RESINS

Property	Birch impregnated with 34.5 per cent resin XJ-16235[a]	Birch impregnated with 30 per cent resin BR-15100[a]	Birch impregnated with 30 per cent resin BV-10678[a]
Specific gravity	1.32–1.37	1.35–1.37	1.34
Modulus of rupture, psi	38000–40000	37000–42000	40000
Modulus of elasticity (Bending, psi)	3.45×10^6	$3.0–3.6 \times 10^6$	3.5×10^6
Impact strength (Izod, ft-lb per in. of notch)	7.3	1.4–4.1	6–7
Compressive strength, psi	25000	25000	25000
Shear strength (perpendicular to lamination) parallel to grain	6–7000+	6–7000+	6–7000+
Water absorption,[b] per cent	2.3	1–2	4–6

[a] BR-15100 is a low-molecular-weight water-soluble penetrating and stabilizing phenol resin; XJ-16235 is a plasticized version of BR-15100; BV-10678 is an alcohol solution and of medium molecular weight.

[b] Test specimen 1 in. × 3 in. × $^3/_8$ in. cross-grain, dried 24 hr at 50 C, weighed, soaked 24 hours in water at 25 C, and reweighed.

The foregoing data represent compreg made in standard procedures to develop balanced properties. If special properties are desired, they can usually be obtained in one way or another, sometimes at the sacrifice of other properties or by the use of special techniques. By special treating methods, for example, we have obtained 40 per cent compreg having impact strength of 14 ft-lb per in. of notch, which is just about the ultimate for densified birch without any resin. We have obtained a density of 1.43, water absorption as low as 0.8 per cent, moduli of rupture up to 55,000 psi, moduli of elasticity up to 5,000,000 psi. The shear values can be adjusted over a wide range of cross-plying the veneers or placing them at a slight angle, by densifying from the sides as well as the top and bottom, or by introducing a wave in the plies of the veneer.

COMPREG—A CUSTOM-MADE MATERIAL

It is obvious that, with many of the variables subject to control, compreg is a custom-built material. Since the suitability is not always described by numerically definable properties, any prepared application should involve not only an estimate of properties required and cost allowable but actual trial under the most severe conditions likely to be encountered in service.

Sometimes we like to look forward to what may eventually be available in materials. As a guess, probably rash, some of the properties, which may eventually be expected, are listed in Table 4.

TABLE 4 FUTURE POSSIBILITIES IN COMPREG PROPERTIES

Specific gravity	1.4
Modulus of rupture, psi	48000
Modulus of elasticity, psi	5×10^6
Izod impact, ft-lb per in. of notch	12
Compressive strength, psi	28000
Shear strength, parallel to grain, perpendicular to lamination, psi	8000
Shear strength, parallel to grain and laminations, psi	6500
Shear strength, perpendicular to grain, psi	16000
Water absorption, per cent	0.8

The data in Table 4 seem to be fair limits obtainable in a single material, parallel grain, with practical equipment and procedures.

Many proposed applications for compreg have been listed

(*Continued on page 744*)

TOLERANCE *and* DIMENSIONAL CONTROL

Its Effect Upon Airplane Production

By HAROLD ADAMS

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ONE of the problems confronting the aircraft industry today is the elimination of rework required on assembly to make parts fit. If the solution to this difficulty can be developed, man-hours and hence the cost of airplanes may be reduced as much as 20 per cent. This estimate of savings is used advisedly, because it is based upon exhaustive spot time studies made over a period of years by qualified investigators. Every possible means has been taken to arrive at a complete conception of the problem and then by careful analysis to estimate the man-hours which it is costing the industry.

MAJOR DIFFERENCE BETWEEN AIRPLANE AND AUTOMOBILE PRODUCTION

Actually, this problem of rework on assembly appears to be the major difference between airplane and automobile production. There are few who have studied it who do not realize its seriousness.

At present, between 75 and 90 per cent of the total labor hours on the airframe are spent in assembly work, that is, putting parts together by welding, bolting, and riveting. In a typical case, 85 per cent of the total hours are spent in assembly as against 15 per cent spent in making the parts. Of the 85 per cent, however, about one fourth, or approximately 20 per cent of the total labor hours on the airplane, are spent in making the parts fit before assembly. In other words, more hours are required to make parts fit than originally were spent in producing the parts themselves. A wing rib may take a total fabrication time of one-tenth man-hour, in routing the part to shape and hydropress-forming. It may then take up to two hours of handwork spent in filing, rejoggling, and fitting to make this same rib fit into the assembly jig. In the majority of cases, the same rework operations must be performed on each rib, not simply in isolated cases. In other words, this rib simply is not the correct size and shape to fit into the airplane and mate with its surrounding parts. It has been said that such parts are "uniformly wrong." Only a relatively small number of such cases as this, where 20 times as much time is spent in hand-fitting as in manufacturing, are required to make rework time equal fabrication time over an entire airplane. The same holds true of machined parts. Where these parts must be sent back to be remachined, however, the problem is somewhat more obvious, and in most cases steps are taken to insure that future parts will fit, such as a change in dimensions or in tooling.

The necessity for hand-rework on assembly occurs in all aircraft plants today. It can be seen in any aircraft plant by those looking for it. In the automobile industry, because of the extremely high quantity production to which manufacturers have been accustomed for a long time and because of the terrific price competition with the resultant necessity for manufacturing efficiency, this problem is not so prevalent. The author is not aware whether or not the situation exists in a plant such as Willow Run which was developed from automobile-production experience, but hand-rework on assembly certainly does exist in the aircraft plants which have grown up from small-quantity production.

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WHY HANDWORK ON ASSEMBLY IS NECESSARY

The reasons why handwork on assembly is required are wrong dimensions and wrong tolerances. By wrong dimensions is meant not necessarily wrong dimensions on the drawing, but on the finished parts. By "dimensions" is meant the average dimensions of the parts as fabricated, that is, the dimensions midway between the manufacturing limits. The effect of manufacturing tolerances will be considered separately.

Wrong dimensions result from a number of causes, among which are the following:

1 Wrong dimensions on the drawing result from scaling layouts made on tracing paper which stretches and shrinks with time and humidity, and often from scaling views which have been projected through several rotations with errors creeping in during the drafting work.

2 Build-up of errors in tooling is the result of errors, or rather, slight cumulative changes in dimensions, occurring during the process of taking the dimensions from a drawing or loft board and transferring them to master templates, from master templates to working templates, and from working templates to a form block.

3 Errors in manufacture are the result of misuse of templates and jigs and of different springback from that expected on formed parts. In general, manufacturing errors are due to poor workmanship and to variations between tooling and parts.

When the cumulative errors in dimension cancel out or compensate on mating parts, no assembly trouble results. When they add up or go in opposite directions on mating parts, then the parts must be reworked in the assembly. With all the possibilities for errors which have been outlined, it is obvious that quite a considerable percentage of parts may require rework on assembly.

WRONG TOLERANCES

Sometimes, especially on assemblies of machine parts, even when nominal dimensions would result in satisfactory assembly, interference or malfunctioning of operating parts still occurs. This is ordinarily the result of an accumulation of tolerances with consequent trouble even though all parts are manufactured within the drawing limits. Errors resulting from improper nominal dimensions are less likely with machined parts because fixtures are built, and in many cases parts are machined directly from the drawings, without the intermediate stages of template and form block as in the case of sheet-metal parts.

The solution to the problem of rework on assembly for airplanes in production is rather obvious. It consists of a se-

quence of three steps, (1) observation, (2) analysis, and (3) correction. The first requires a crew of trained observers and analysts to determine whether engineering, tooling, or manufacturing errors exist, and to determine what correction is required. Often a specific difficulty may be corrected most economically by a compensating error on a mating part or rather by a difference from the drawing dimensions on the mating part. It horrifies engineers to keep parts in production which differ from drawings. Nevertheless, it is often the most expedient means of correction and of reducing shop labor hours. If the airplane is just going into production, however, or if it is to be subcontracted, then the cure which will prove most economical in the long run is complete correction of drawings, tooling, and manufacturing to make the parts truly accurate.

As engineers we are more interested in the solution of the problem on a new airplane or, rather the prevention of the necessity for rework on assembly. This solution cannot be found wholly in engineering, in tooling, or in manufacturing, but must be a co-ordinated effort on the part of all three based upon a uniform policy.

THE ENGINEER'S CONTRIBUTION TO A SOLUTION

The major part of the solution does lie in engineering; certainly the first step must be taken by the engineering department. This step may be divided into three parts, as follows:

1 Design to avoid the necessity for close dimensions. In other words, design to avoid overconstraint. A three-legged stool always rests on the floor without rework but a four-legged chair often requires rework to make all four legs touch the floor at the same time. A four-legged chair is overconstrained since a stable structure requires only three points of support. Coming a little closer to airplanes, intercostal members with end clips need not have close dimensions or tolerances, as an overlapping end clip may be slid along to provide adjustment. This solution, designed to avoid overconstraint, is the best in many cases and is almost the only one possible for machined parts. In many cases, however, as indeed in the case of loose end clips on intercostal members the cure is sometimes worse than the disease, for additional labor hours must be spent in fabrication and assembly of these loose pieces. Usually, avoidance of overconstraint is the most satisfactory solution when it does not complicate the design.

2 Exact dimensioning of sheet-metal parts should be practiced. The automobile industry uses a drawing on metal called a "body draft" on which all dimensions must add up since the entire automobile is drawn on one piece of metal and discrepancies in dimension would be obvious. By this method the automobile is "assembled in the engineering department." This method is already being applied in the aircraft industry and appears to have possibilities of greatly reducing errors in dimensions. The calculation of rotated dimensions to keep dimensions in projected views free from error is a necessity when exact dimensioning of parts is required. With the use of metal layouts and the calculation of rotated dimensions, the major engineering causes of wrong dimensions disappear.

3 Proper tolerances must be applied. Wherever small clearances must be held, or wherever overconstraint appears, it becomes necessary to consider the effect of accumulation of tolerances. All drawings of parts carry a tolerance on dimensions because it is universally recognized that no part can be made to an exact dimension. The effect of the accumulation of these tolerances in assembly can be determined by making a tolerance check. A simple example is a piston in a cylinder; if the piston is to move inside the cylinder, the piston, when made to the largest dimensions permitted by the drawing, must still be smaller than the smallest cylinder which the drawing tolerances permit.

This is a simple case. The stroke of the same cylinder, however, may be a much more complex case since the stroke may be affected by the tolerances on as many as ten or fifteen dimensions. If we were to try to check the effect of all the possible combinations of all of these tolerances, the task would be an almost impossible one. However, there is a simpler solution, consisting of two steps:

(*a*) Selection of the points where an accumulation of tolerances might cause trouble. Generally, this means all the places where a small clearance, a small overlap, or thin section is controlled by the build-up of half a dozen or more tolerances, bearing in mind that if each of six dimensions is plus or minus 0.010 in., the total variation will be plus or minus $^1/_{16}$ in.

(*b*) Calculation of the clearance or overlap taking all tolerances in the adverse direction. It is true that chance will not ordinarily result in an assembly having all tolerances adverse. However, this calculation does make tolerance checking possible and compensates for machine errors and inspection errors which occur and which are passed by salvaging procedures.

If this or some other suitable method of tolerance checking is used, rework on assembly, or selective assembly resulting from an accumulation of adverse tolerances, is unlikely.

POSSIBILITIES OF IMPROVEMENT IN TOOLING

Next to engineering, the greatest possibilities for elimination of rework on assembly lie in tooling. As in engineering, there are three parts to the solution:

1 Reduction in the number of steps from the source of information to the final parts. An extreme example of reduction in number of steps from drawing to part is the use of a drawing reproduced photographically on metal on which the part will be made, thus introducing only one possibility for error, or one chance for change in dimensions, rather than the usual three or four.

2 Reduction in the amount of change during the steps from drawing to part, that is, improvement in accuracy of each step. The photoreproduction process and the use of mathematical curves which can be re-laid-out rather than transferred, both reduce the accumulated error involved in transferring loft lines and reproducing templates, thus improving accuracy.

3 Proving that tooling is satisfactory by comparing parts made from tools with the source of information. This is particularly easy when the original source of information is a metal layout on which the actual part can be placed for comparison. This requires, of course, the setting up of a system for making this comparison. The comparison of parts directly with the source of information also tends to reduce manufacturing errors and makes recognition of such errors immediate.

CONCLUSIONS

To summarize the effect on airplane production of tolerance and dimensional control, we can say that a problem exists, the solution of which may reduce man-hours spent in airframe production by as much as 20 per cent; that this problem is the elimination of rework on assembly necessitated by parts that do not fit; that the reason why the parts do not fit is because of wrong dimensions and wrong tolerances; that the cure for existing airplanes is observing, analyzing, and correcting the troubles which do exist; and that the cure for a new airplane is in engineering, designing to avoid overconstraint, exact dimensioning and application of correct tolerances, and in tooling, reduction in the number, and improvement in accuracy, of the steps.

Work is being done on this problem, but awareness on the part of all concerned, and especially of all engineers, will do much to speed up the arrival of the final solution with its resulting increase in production of the planes which are so urgently needed at the battle front today, and which will be so urgently needed to hold America's place in the competition for aviation supremacy after the war.

WHICH INDUSTRY TO CHOOSE[1]

By DONALD S. TUCKER

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AT THIS time the review of any book on investment policy may seem highly inappropriate to many patriotic readers. Admittedly, everything we can save now should go into war bonds. For older savers, however, there are still the problems of the occasional investment shift. Such at least must be the excuse for reviewing at this time a book that discusses only the securities of business corporations.

The stimulating volume[2] selected for examination in this issue was published nearly four years ago; but month after month it has been pushed aside, because works on the selection of private investments have seemed less immediately significant than those treating some of the manifold public problems created by new labor conditions or by war. Even at this late date two recent works on public problems were with some hesitation laid aside in order to describe this outstanding work before time makes its illustrations obsolete. Its contribution, fortunately, is in no danger of obsolescence.

Selection of the specific security after a company has been selected for investment is in the opinion of Mead and Grodinsky a matter of relatively little importance. Many of the best enterprises issue only common stock. This book (p. 435) states: "It is the concentration of investment analysis upon income statements and balance sheets to which many investment tragedies can be traced. . . .A given margin of earnings over interest charges is given the same weight in the profitable as in the unprofitable industry." Because of their condemnation of such blindly statistical approach these authors relegate selection of the specific security to brief space; and even within this space their discussion is devoted chiefly to criticism of the present emphasis on this topic. Of twenty-five chapters then only one is devoted—even nominally—to selection of the specific security.

Selection of the corporation or enterprise within the chosen industry receives rather more attention. Five chapters are devoted to this choice. The importance of management is emphasized; but the aspects of management receiving chief emphasis are its financial policy and its capacity to find new products for exploitation. Wise selection of new products and such administration of existing assets that the exploitation of new products can be financed at any time are in fact almost the only aspects of management regarded as worthy of extended examination by investors. Obsolescence is latent in all enterprises (chapter 16); the prime task of management then is to move with the changes of public taste and to administer its existing investment in such fashion that the necessary movements are always possible. Labor policy, engineering efficiency, purchasing policy, and even marketing must, if necessary, be delegated to subordinates. The task of a top management is to keep its enterprise always in an expanding industry; but for an investor the prime task is to select only enterprises which are engaged in industries of the correct stage of maturity.

Industries pass through three stages which these authors distinguish as the pioneering stage, the stage of expanding demand, and the stage of declining demand. Commitments should be made only in companies whose industry is in the second of these stages. The investor's first problem then is to satisfy himself that the industry to which his company belongs has emerged from the pioneering era.

During the pioneering stage the demand for a product may expand with extraordinary rapidity. Large fortunes are frequently made; but the industry is not yet ripe for the lay investor. (1) Within the industry it is not yet certain which companies have the specific products that will survive. (2) Technical insolvency is exceptionally frequent. The very rapidity of expansion may compel a management to assume debts. Unforeseen contingencies may compel default. It is then small comfort to the stockholders of a defunct concern to know that the assets which they formerly held are now earning a magnificent income for new owners.

The automobile industry, in the opinion of these authors, did not emerge from the pioneering stage until about 1929 or 1930. Who in 1925 could have predicted the bankruptcy of the Studebaker Corporation? Who could then have predicted that the bankrupt Maxwell enterprise would become so highly profitable for new owners? The ordinary investor must learn to wait until an industry has settled down to regularity and order.

The investor's next problem is not to wait too long. Industries pass their crest. It is the growth of new pioneers that makes older industries obsolete, and this book's greatest contribution lies in the aid it gives to investors in determining when to sell. Eight chapters are devoted to factual material indicating the modern trends of demand. Nine additional chapters are devoted to the analysis of elements which indicate the desirability of disinvestment or sale.

Disasters appear suddenly and may overwhelm a whole industry. After a disaster has occurred, it is then too late for the investor to rescue any large part of his commitment. "The *event* of capital and income loss is sudden; the forces leading to the event are years in the making." For many investors then the most significant portion of this book will be the five chapters specifically devoted to the symptoms of decay. These include stationary demand, betterments, movements of productive capacity, price advances, debt and (p. 445) slight increases in the yield of the common stock of companies engaged in the undesirable industry.

"Costs are reduced by the installation of betterments;" but "this relative concentration of expenditures on efficient mechanization. . . is a symptom of decay" (page 334). In the transition from expansion to decline corporations have usually good credit as a result of previous years of high profits. Cost-reducing improvements are financed readily. These improvements, however, enlarge fixed expenses while reducing direct costs. They make any subsequent diminution of sales more disastrous. Only in the later stages of decline, however, does a company's credit become so poor that the financing of betterments becomes impossible. The authors' conclusion (page 399) is that "the declining industry is not likely to recover its earning power by reducing its costs. Based on the New York Stock Exchange record, it has never done so."

The only corrective likely to succeed is the substitution of new products for which there may be an expanding demand. Such substitution is possible if (1) the plant is flexible, if (2) the corporation is well supplied with cash, and if (3) the management and its technical staff are also sufficiently flexible; but alteration of the nature of a company's product is difficult or impossible for (1) the producers of a raw material, and for (2) industries that supply services "by the use of a costly specialized

(*Continued on page 744*)

[1] One of a series of reviews of current economic literature affecting engineering, prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS. Opinions expressed are those of the reviewer.

[2] "The Ebb and Flow of Investment Values," by E. S. Mead and J. Grodinsky, D. Appleton-Century Co., New York, 1939.

Training WOMEN *for* ENGINEERING TASKS

By E. D. HOWE

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THERE are three major questions which may be asked in connection with the training of women for engineering tasks. They are as follows:

1 Is there a real shortage of male engineering workers so that women must be used?

2 Are there particular engineering tasks for which women may be trained as readily as they are trained for stenography or other business-office tasks?

3 Can women capable of doing these engineering tasks be found and trained?

The first question can be answered in terms of the publications of the War Manpower Commission, and the other two in terms of the work done by Engineering Science and Management War Training Programs, such as the one operated by the University of California. The present paper is an attempt to suggest some of the answers to these questions.

THE NEED FOR EMPLOYING WOMEN

The present situation with regard to engineering work in war industries has many aspects, one of the most important of which has to do with the supply of engineers. Reference is made to a bulletin of the National Roster of Scientific and Specialized Personnel[1] which deals with the professional engineer, that is, the college graduate or person of equivalent technical attainment. The situation as of January 1, 1943, is given statistically in this bulletin, and estimates are made of the need for the 6 months ending June 30, 1943. The figures given indicate that of the 280,000 engineers in the country, 105,000 were engaged in manufacturing and 53,200 were in the armed forces as of January 1, 1943. In the 6 months period between January 1, 1943, and July 1, 1943, 12,000 engineers were needed by manufacturing and 13,000 by the armed services, a total of 25,000. The senior classes of all the engineering colleges in this country contain a total of 17,000 engineers, of whom 6400 are already members of the armed forces by virtue of reservist status. Furthermore, the age of the graduating senior makes him more desirable to the armed forces than older engineers. Hence it seems probable that the number of graduating seniors who would enter industry would not greatly exceed the 4000 differential between the supply and the needs of the armed forces. The other 8000 must, therefore, be transferred from other types of engineering work or must be substituted for by other means.

Another important factor in the supply of engineers is that of the entry into the armed services of practicing engineers. Since this is largely a function of the median age of the engineers, the figures given by the bulletin[1] are of interest, Table 1.

It should be borne in mind that not all of the engineers entering the armed forces will be engaged therein with engineering work. Those who enter the armed forces in other than engineering work must be considered as lost in so far as the supply of engineers is concerned. From Table 1, it is seen that nearly one half of all engineers and about three fourths of the aeronautical engineers are subject to Selective Service calls, thus the transfer of engineers from other branches will be limited.

TABLE 1 MEDIAN AGE OF ENGINEERS IN VARIOUS FIELDS

Fields	Per cent under 38 yr	Median age in years
Aeronautical engineering	78.0	29.9
Chemical engineering	70.5	30.1
Radio engineering	67.8	33.9
Electrical engineering	49.1	38.3
Mechanical engineering	48.0	38.9
Mining and metallurgical engineering	44.1	40.3
Marine engineering and naval architecture	41.6	42.1
Heating and ventilating engineering	40.9	40.7
Civil engineering	32.8	45.1
All engineers	47.1	39.6

TABLE 2 AIRCRAFT ENGINEERING OCCUPATIONAL OPPORTUNITY STUDY[a]

	Group	Number of men	Rough equivalent percentage
I	Preliminary design and development	27	2
II	Aerodynamics	22	2
III	Stress analysis and control	65	6
IV	Weight analysis and control	40	3
V	Production design, drafting, checking	453	40
VI	Tracing, blueprint, and record work	313	27
VII	Administration, supervision, and liaison	235	20
	Totals	1155	100

[a] Douglas Aircraft Company, Inc., October 1, 1940.

With these facts before it, the National Roster suggests the employment of women in the following excerpt from its bulletin:[1]

"The effect of a shortage of engineering personnel . . . . can be ameliorated by increasing the supply, by restricting the use, and by increasing the effectiveness of the use. . . . .

"The effectiveness of use is being and may be even more increased by turning over the simpler engineering tasks to technical assistants, by "exploding" or "diluting" jobs and having the parts performed by men and women with limited technical training, and by improving the technical ability of engineers through such training as is given in the ESMWT."

The training of women under the War Training Program is intended to furnish technical assistants to perform the "exploded" and "diluted" jobs.

ENGINEERING JOBS FOR WHICH WOMEN SHOULD BE TRAINED

Turning now to the nature and magnitude of the engineering work to be done, it is necessary to consider some particular industry. Although graduates of the University of California war training courses are at work in many small industries, in shipyards, and in civil service, the large majority are employed in the aircraft-manufacturing plants. Fortunately, there is

Contributed by the Aviation Division and presented at the Semi-Annual Meeting, Los Angeles, Calif., June 14–17, 1943, of The American Society of Mechanical Engineers.

[1] "The Personnel Situation in Engineering," Bureau of Placement, National Roster of Scientific and Specialized Personnel, Bulletin No. 3, April 14, 1943.

available for the aircraft industry a detailed summary of the engineering jobs and the types of persons required for those jobs. This summary, prepared by C. T. Reid[2] of the Douglas Company, deals with conditions in 1940 and is regarded as sufficiently recent to be applicable at the present time. Table 2 is taken from Mr. Reid's paper.

It appears from the text of the paper[2] that engineers with the technical information of the engineering-college graduate are required for only the first four groups listed in Table 2, or a total of 154 persons. The requirements for the next two groups, are listed by Mr. Reid as follows:

GROUP V PRODUCTION DESIGN, DRAFTING, AND CHECKING

Qualifications Required:

Knowledge of materials and manufacturing practices used in modern aircraft construction.
Knowledge of drafting-room practices and standards used in modern airplane construction.
Knowledge of government requirements affecting detail design and drafting.
Familiarity with government specifications for aircraft materials.
Ability at simple stress analysis for strength check of details.
Fundamental knowledge of mechanics and machine design.
Neat accurate drafting.
Good practical working knowledge of trigonometry and descriptive geometry.
Specialized knowledge of one line, such as structures, surface controls, interior furnishings, installation of power plant, installation of electrical system, installation of hydraulic system, etc.

GROUP VI TRACING, BLUEPRINT, AND RECORD WORK

Qualifications Required:

Skill at mechanical drawing, accuracy at simple figuring, ability at English composition, reasonable finger dexterity.

Groups V and VI contain 766 persons, or 67 per cent of the engineering personnel. Consideration of the qualifications required for these jobs leads to the conclusion that a complete engineering education is not required and that persons could be fitted to do the work concerned after relatively short but intensive training courses. It is further concluded, that women could be trained as readily as could men with no previous knowledge of engineering or manufacturing. In addition to the jobs involved in groups V and VI, there are portions of the jobs in the other groups which can be done by subprofessional persons trained as stress computers, weight computers, laboratory observers, all tasks for which women are well suited. Thus in aircraft engineering women should be trained for jobs such as draftsmen, computers, and laboratory observers. In other war industries, the results of a like survey would doubtless be similar.

RECRUITING AND TRAINING WOMEN

In this section of the paper it is proposed to discuss the War Training Program of the University of California as related to the training of women. The University of California has trained and placed 1264 women in engineering work since February, 1942, in Southern California. Since the bulk of the trainees have entered the aircraft industry as draftsmen, either in product engineering or in tool engineering, the discussion will center about the training for aircraft drafting. The successful operation of this training program involves three operations, as follows:

1 Planning for length and content of the course through an appraisal of the job such as given by Reid.[2]
2 Recruiting, selection, employment of suitable trainees.
3 Selection and instruction of the teaching staff.

Planning for Course Length and Content. This is normally done by conference between the University educational supervisor and the educational and engineering representatives of the company concerned. Experience to date appears to indicate that a full-time course lasting twelve 40-hr weeks is sufficient to make a beginning detail draftsman from a person who has graduated from high school with mathematics, including algebra and geometry, and who possesses reasonable intelligence and manual dexterity. The subject matter included in the course covers the following fields:

Review of algebra and geometry
Applied trigonometry
Technical drawing
Aircraft drafting (company standards, etc.)
Aircraft materials
Aircraft fabrication and assembly methods

Examinations are scheduled at frequent intervals for checking the progress of the students in the several subjects.

Recruiting and Selection of Students. The recruiting and selection of students, in so far as the University is concerned, is carried on by the Co-ordinator of Women's Training and her staff of interviewers. When the course is to be given for a particular company which pays the trainees to take the course, the recruiting is a joint venture in which the University co-ordinator collaborates with the company personnel department. Since much of the success of the training program depends upon the quality of trainee selected, it is essential that the tra nee be both "employable" in so far as personality is concerned, and capable of doing the work. An Otis intelligence test is used as a rough screen and is followed up by a personal interview. Manual dexterity is estimated on the basis of other accomplishments of the candidate, such as painting, art work, sewing, typing. Enforcement of the minimum prerequisites of algebra and geometry is important and is emphasized by experiences with persons admitted previously with substitute training or experience.

When the course is one in which the students are unpaid, the Co-ordinator of Women's Training arranges for personnel men from various companies to visit the class and interview the

TABLE 3 ANALYSIS OF FULL-TIME COURSES[a]

Course Titles	Trainee	Unpaid	Total
Aircraft drafting	31	10	41
Engineering drawing	12	3	15
Advanced engineering drawing	2	..	2
Engineering fundamentals	..	1	1
Introduction to tool design	27	..	27
Aircraft engineering lofting	1	..	1
Plane surveying	..	1	1
Production illustration	1	..	1
Ship drafting	..	1	1
Elementary stress analysis	2	..	2
Total	76	16	92

[a] Offered since March, 1942, when first class was opened.

ENROLLMENT IN COURSES

	Men	Women	Total
Preplant	745	1058	1803
Inplant	769	100	869
Total	1514	1158	2672

TABLE 4 QUESTIONNAIRE SURVEY, FEBRUARY, 1943

(Pre-employment, full-time classes March 22, 1942–January 8, 1943)

Number of questionnaires sent	187
Number of questionnaires returned	159
Promotions:	
Total number of promotions	138
Number of people receiving promotions	86
Number of pay promotions received	100
Number of classification promotions received	38
Number of persons who received more than one promotion	60
Number of persons working with original company	147
Number of persons who have changed companies	8
Number of persons not employed	11

[2] "What the Aircraft Industry Expects of the Engineering College," by C. T. Reid, *Journal of Engineering Education*, vol. 31, March, 1941, pp. 460–472.

students during the last week of the course. Placements in such classes have run very high in percentage.

Selection and Instruction of the Teaching Staff. The teaching staff in a drafting course is generally built around a man borrowed from the industry for the purpose of furnishing an up-to-date knowledge of industrial standards and practices. His efforts may be supplemented by those of experienced drafting teachers on leave from local colleges and by part-time teachers of mathematics. The staff is selected by the University Educational Supervisor and works under his direction. The supervisor contributes his knowledge of engineering and of teaching through periodic conferences with the instructor, and through visits to the classroom and reviews of students' work.

RESULTS OF THE PROGRAM

The statistical data regarding the several full-time training courses have been summarized as of May 1, 1943, by Miss Mildred Foreman, the Co-ordinator of Women's Training, in a report to the local office of the War Manpower Commission This summary appears in part, in Table 3.

The persons who have received training, as in Table 3, are now working in Southern California industries. A return-mail survey of persons who had completed the training was recently made. The questionnaire was sent to 187 person who had completed courses 1 month or more prior to the survey. Replies were received from 159. Results are summarized in Table 4.

The training of women for these tasks has met with an enthusiastic response from the women. The 10 or 12 weeks preparation time involved is about the same amount of time as ordinarily spent in specialized study by women who wish to do stenographical work. Drafting and other engineering tasks are attractive to some women because they involve less routine than does stenography or other office work. The women trained by the University of California are enjoying their work and are in the main doing it well.

Therefore it seems to the author that the period after the war will find many women engaged in these engineering tasks much as they are now engaged in stenography and related office tasks. The question may be asked as to the probability of large numbers of women being trained and working as engineers. This does not seem reasonable to the author since the investment of time and effort involved in an engineering education is much greater than is warranted by the relatively brief space of time during which the average girl works between the end of her school days and the beginning of married life. There are now a number of successful women engineers who have made this work their life careers. This number will probably increase in the future but not amount to a very large proportion of the professional engineers.

Resin Impregnation of Wood

(*Continued from page 738*)

but by far the most important present use of compreg is in propeller blades for aircraft. The English have long used several types of resin-treated or resin-bonded and densified wood blades and the compreg blade is now in successful production and use in this country. Test clubs have been molded for some time, utilizing a process in which the blank is preheated by high frequency, then molded and densified in a heated press. Ventilating fans appear to be a legitimate field for treated wood, because of its mechanical properties and resistance to corrosive atmospheres.

For many years electrical insulating parts requiring high strength and shock resistance have been made of resin-impregnated and densified wood. Compreg is also used to take the concentrated stresses of fastenings at the root of wing parts.

Ski and sled runners faced with compreg are faster and wear better than the plain wood. A small but interesting use for compreg is for parallel rulers where hardness and freedom from warping are required.

Development of decking of impregnated and partially compressed plywood has long been under way. The stabilizing, waterproofing, and hardening effect of the treatment may render it worth while for certain types of boats.

Probably one of the most promising of the many suggested applications for impreg is as the face ply in the skins of some plywood aircraft and in the shells of boats, pontoons, and other structures requiring special water resistance. These items are in production and current use. We see no justification for considering dense compreg in aircraft skins or in any such structure where stiffness for weight is important.

Earlier we had envisioned numerous peacetime applications as in furniture, paneling, housing, and luggage but these naturally do not now receive attention.

Compreg and impreg have definite purposes to fulfill as engineering materials and we are continuing our work to develop them properly for those purposes.

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Which Industry to Choose

(*Continued from page 741*)

plant." In the opinion of these authors then the investment attributes of the steam railroads of the United States are peculiarly unfortunate.

Common stock, because its market is always speculative, may often be sold even when disaster impends. The small investor, if alert, may even sell also a small block of high-grade bonds; but the large-scale liquidation of high-grade bonds is substantially impossible. In the winter of 1937–1938 the sale of less than five per cent of the Baltimore and Ohio first mortgage 4s of 1948 caused the price of that issue to be cut in half. "What the composite investor buys he cannot sell" is peculiarly true of securities of the highest grade. For this and other reasons the wisdom of present statutes regulating the investments made by trustees is questioned sharply.

Because of its absorption with one aspect of the investment problem, this work should be called a monograph rather than an investment text. Its importance lies in the fact that within its chosen field—the selection of the industry—it does the first comprehensive job that has yet been done. Less detailed in its comments than Fraser and Doriot,[3] it is nevertheless more helpful to the investor because the comprehensiveness of this new survey permits the revelation of tendencies which are highly significant. It covers thus precisely the field in which other investment texts are most deficient. Historical summaries of the progress of 113 industries (1923–1936) are presented in chapters 6–8. These alone may seem well worth the price of the book to many investors.

[3] "Analyzing Our Industries," by C. E. Fraser and G. F. Doriot, McGraw-Hill Book Company, Inc., New York, N. Y., 1932.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

Education for Management

To the Editor:

In the issue of Mechanical Engineering of July, 1943, there is an article headed "Education for Management" by Harold Vinton Coes, President of The American Society of Mechanical Engineers. This article outlines the pretty well-standardized method of operating an organization whose purpose is production.

The organization outlined by Mr. Coes would follow very closely that of the military and is dependent for its success on the ability of the man at the top. He not only lays out the direction which the organization is to go but directs in detail how it shall get there.

There is no doubt that many organizations are successful when organized along this line. However, I wonder if such an organization is the ultimate or even progressive? The ability of any individual, as the top of any organization, must be limited. Put another way, the combined abilities of all the people in any organization are very much greater than the ability of any one man, no matter how good that one man may be. In any able organization there is almost certainly someone who knows more about any subject than does the man at the top.

Under the type of organization outlined by Mr. Coes it is perfectly obvious that this ability is not going to be used except in a secondary way, in spite of the fact that Mr. Coes makes it very plain that suggestions are to be made by the subordinates. However, there is no possibility of individual suggestions being accepted in such an organization unless they fit into the pattern which is already in the mind of the chief executive; in fact, there would be no other way for such an organization as outlined to function.

If American industry is to retain its position of world leadership, we must go further than the organization outlined by Mr. Coes. We must use the individual talents of the whole organization.

If that is to be done, it is impossible to have clean-cut lines of authority. It is impossible to have a line and staff organization as such. A goal in which all believe must be set and the individual abilities of each must be used in arriving at that goal. Each job must be done by the person most able to do it. This is a much more difficult job for the chief executive but it is tremendously more efficient when accomplished. This job has been done in practice and will be more popular as greater experience develops.

That is the direction we must go if we are to retain world industrial leadership. That is the direction of progress.

J. F. Lincoln.[1]

To the Editor:

In response to J. F. Lincoln's discussion of my paper entitled "Education for Management" I must disagree with the conclusions which he drew from it.

I agree with Mr. Lincoln that the ability of any individual, at the top of any organization, must be limited. However, I do not agree with him that an organization cannot be manned from top to bottom with competent officers, executives, keymen, and staff men who can provide the top executive with the necessary basic information and, in discussion with him, enable him to draw sound conclusions from the facts, as the basis for policy formulation or executive decisions. The foregoing statement is based on the assumption that the subordinates of the chief executive are at liberty to disagree with him and are not just "yes" men. If they are, then that is the fault of the chief executive himself. I admit that there are chief executives who do not like to be crossed, and I have seen times when it was hazardous for a member of an organization to cross or disagree with his chief. But that was not the fault of the organization structure, or of the type of organization. It was a defect of the chief executive, and no form of organization can prevent that.

I also agree "that the combined abilities of all the people in any organization are very much greater (or should be greater) than the ability of one man." But I do not agree that "under the type of organization outlined by Mr. Coes it is perfectly obvious that this ability is not going to be used except in a secondary way . . .," to quote from Mr. Lincoln, for the reasons previously cited.

An organization chart is not an end in itself. Unless competent people are selected for the various positions and suitable and adequate authority is delegated to them, commensurate with the responsibility imposed by the job, the organization will not function as it should, and the top layer of executives and the chief executive himself will be forced to make decisions that should have been made by those in lower managerial positions.

I am at a loss to comprehend what form of organization Mr. Lincoln has in mind, when he says, "It is impossible to have clean-cut lines of authority. It is impossible to have a line and staff organization as such," unless he contemplates an organization operating as a committee of the whole, and that would be like Congress acting in an executive capacity. One can well imagine the results.

Mr. Lincoln says that you cannot have clean-cut lines of authority and that it is impossible to use line and staff organization because one cannot secure the combined abilities of the organization or their suggestions if their authority is delegated or a staff organization is used. I absolutely disagree with that. How an organization functions, how the abilities of its members are developed, encouraged, and co-ordinated, how members of an organization are recognized and promoted is totally independent of the form of organization but is absolutely dependent upon the philosophy, the type of thinking, the breadth of view, the ability and leadership of the top management.

I have seen more organization morale damaged by failure to delegate adequate authority, to recognize that authority goes with the job, and by failure to define the job with respect to line and staff jobs, than I have where these assignments are thoroughly and carefully made.

Again, the morale of an organization, besides the effect on it of the foregoing possible damage, is dependent upon the philosophy, the attitude, the leadership of the top management, and not upon the mass. It will respond to fair, competent, unbiased, courageous leadership.

I agree that the job should be done by the person best able to do it, but again this is only possible when there is a clearly defined policy by management of making job assignments on the foregoing premise.

Finally, decisions must be made, either by the chief executive or, if the business

[1] President, The Lincoln Electric Company, Cleveland, Ohio. Mem. A.S.M.E.

is operated on a committee basis, then by that committee. I do not understand that operation on a committee basis, as tried in Russia, has proved successful. There they have had to change over to an individual responsible executive basis.

Mr. Lincoln has not made it clear who makes the decisions, and how they are made. Since he states positively that it is impossible to have clean-cut lines of authority he does not make it clear how he would obviate dual and overlapping responsibility and authority and the resulting confusion and demoralization.

HAROLD V. COES.[2]

[2] President, A.S.M.E., vice-president, Ford, Bacon & Davis, Inc., New York, N. Y.

Skill and Effort Rating

TO THE EDITOR:

At present there are two methods of teaching skill and effort rating to new time-study engineers: (1) The showing of moving pictures and having the student rate the operator performing certain elements or tasks; (2) the timing and rating of shop tasks which have been studied by experienced engineers. Both methods are questionable because they are based upon the idea that subjective ratings placed upon the tasks in the beginning by experienced engineers are accurate. This is open to as much question as judging the speed of a passing car by several experienced motorists; one might judge the speed at 35 miles per hour, another at 40, and still another at 45, the percentage difference between the extremes being 29 per cent!

The only sure way of testing the rating skill of inexperienced (and experienced!) time-study engineers is to start with tasks about which some quantitative data have been established. Walking is one such task. If 2.8 miles per hour is the average speed of a man walking under no-load conditions on a flat horizontal surface, then this would seem to offer one method of teaching or learning rating accurately. Remember, this 2.8 figure is not the judgment of even the most experienced time-study observers; it is an empirical figure obtained from thousands of walkers; it is a figure, moreover, which can be maintained without undue fatigue.

In one minute, then, a "normal operator" should traverse a distance of 246 feet. A course laid out in a room which will add up to 246 feet (or half of it for half a minute) will prescribe the unit of measurement. Even self-teaching of elementary rating may be done under these conditions by having someone—anyone—walk this distance and noting the time taken and rating the "operator" *before* the end of the "work cycle" (before the end so as not to be influenced by the time actually taken).

If the course chosen were 123 feet, the perimeter of a large-sized room, and the time taken just 0.50 minute, then the observer would be in error if he rated the operator 70 instead of 60 (normal). By the same token he would be in error if he rated the operator 60 and the time taken were 0.55 minute. (What should the rating have been?)

There is another common operation about which there has been a great deal of quantitative study—typing. The speed of the average ("normal") office typist is 57 words a minute (five letters—strokes—to the word). This, too, is a convenient operation to study, especially where typewriters are equipped with cyclometers.

The technique to be followed is similar to that of the walking experiment. There is no need to take the word of the office manager as to who is average and who above average. A watch and a count of the number of strokes at the end of the interval of time (285 at the end of a minute) is all that is necessary. If a number of operators can be observed, so much the better; if not, tell the one typist to vary her speed from one "cycle" to another. Remember, though, the rating must be done before the end of the time cycle—long before, if practical—so as to get rating judgments that are based on motion-analysis rather than stop-watch results.

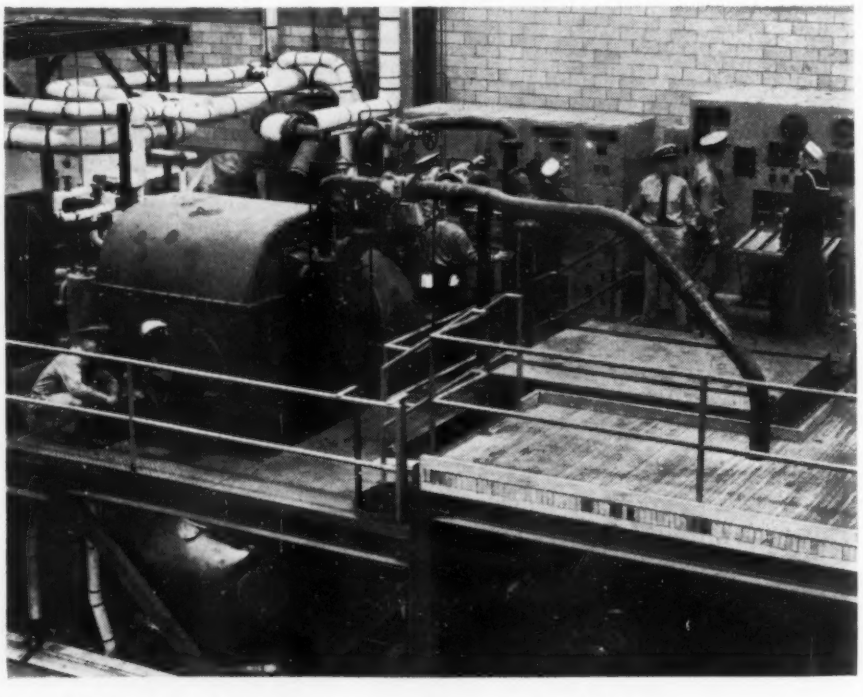
There are other tasks about which quantitative data have been gathered. The point to be stressed is: Empirical data must first be collected before rational rating can be started. It is reasonable to suppose, then, that an engineer (experienced ones, too) who can rate (judge) accurately 5 or 10 of these empirical tasks can be trusted to rate other tasks about which there have been no far-reaching production studies.

H. R. NISSLEY.[3]

[3] Associate Professor, Kent State University, Kent, Ohio.

Correction

On page 528 of the July issue in Table 3 the fifth and sixth lines should read "Conductivity at mean temperature, Btu in. per sq ft per deg F per hr . . . 1.05. The last line in the table should read "per day."



"LAND SHIP" ENGINE ROOM OF U.S.S. "KNOX"

(Navy men who will form the nuclei of operating crews for many of the destroyer escorts are taking an intensive training course at General Electric's Syracuse plant in the operation and maintenance of turbine-electric propulsion sets which the company is manufacturing there for the new-type vessels. The 30-day course, conducted by General Electric at the request of and in co-operation with the Navy, is designed not only to teach the men how to operate the equipment but also to disassemble and assemble it with confidence and familiarity that would be difficult to obtain otherwise. This objective is considerably facilitated by the U.S.S. *Knox*, recently christened "land ship" which consists of a complete destroyer escort engine room, shown in the illustration, permanently installed in the plant for study. The engine room and the location of its component apparatus—the main turbine-generator, condensers, propulsion motor, control board, pumps, and auxiliaries—is exactly the same as aboard ship. Moreover, it can be operated under conditions simulating those at sea.)

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Thermodynamics of Firearms

THERMODYNAMICS OF FIREARMS. By Clark Shove Robinson. McGraw-Hill Book Co., Inc., New York, N. Y., 1943. Cloth, 6 × 9 in., 175 pp., 31 figs., $2.50.

REVIEWED BY LIONEL S. MARKS[1]

THIS is a textbook on interior ballistics. Although it contains only material known by experts in its field and available in book and periodical form, it is unique in that there is no equivalent work on the subject in the English language.

The relationships between time, pressure, velocity, and travel for a projectile in a definite gun are calculable when the pertinent data are supplied. Consequently the probable performance of firearms can be estimated, and modifications in ammunition to meet changes in requirements for existing guns can be determined with adequate accuracy. There are two methods of attack. One method depends on the use of statistics and empirical relations; this usual method is relatively simple and suitable for interpolation. The other method demands a knowledge of complicated physical and chemical data and the application of thermodynamics; it is laborious but is more reliable for extrapolation. The avowed purpose of this book is to emphasize the second method, which up to now has not been available in English.

Ballistics is the art of hurling a projectile. Interior ballistics deals with the projectile and its accessories while it is within the gun. It includes all the operations from the instant of firing the primer mixture until the projectile and the powder gases have left the muzzle. It involves studies of ignition, the rate of explosion of the propellent, the temperature, composition, and pressure of the products of combustion, the travel of the projectile and of the powder gases in the bore of the gun, and such external effects as heat, flash and smoke, and recoil. The design of the propellent must also be included, and this involves a knowledge of the chemical and physical-chemical relationships of powder and of powder gases.

The author devotes the first portion of his book to basic theory. He starts with thermodynamic principles which cover not only the customary treatment of the perfect gases but also the data requisite for dealing with actual gases at very high pressures and temperatures. Procedures are included for dealing with heat capacities at high temperatures and pressures, such as that due to Weber. Basic mechanics and basic physical chemistry follow. Reaction rates and equilibrium constants are discussed and values given for propellent powders and their products of combustion. There are tables giving heat of explosion and heat of formation on more than a hundred propellents, and this is followed by a chapter on the calculation of explosion temperature and pressure by three different procedures, taking into account the heat loss to the container and the relatively unimportant loss due to its expansion.

One of the most important chapters is that dealing with rate of explosion, which includes an analysis of various formulas which have been proposed as representing the rate of pressure rise back of the projectile. The influences of loading density, of the surface factor, and of the propellent-powder composition are duly considered in this connection.

Further chapters deal with the rotation of the projectile and with the friction losses due both to the cutting of grooves in the rotating bands of the projectile, and also to the resistance to travel. Here, as elsewhere, the pertinent experimental results are given and also the theory, so far as it has been developed. Further chapters deal with the stability of propellents, the measurement of pressure and of temperature within the gun barrel, and closed-chamber or "calorimetric-bomb" experiments with various propellents. In connection with the last item, the work of Crow and Grimshaw, which is unexcelled in quality and reliability, is considered exhaustively and is used as a basis for the example of the calculation of interior ballistic curves, which is the final aim of this book.

The author has managed to compress into 147 pages of text a valuable summary of what is known on this subject and has added an extensive bibliography for the benefit of those who would go further. The reviewer is not well acquainted with the literature in this field, but so far as his examination goes, he finds the book substantially free from inaccuracies and entirely adequate for its avowed purpose.

[1] Professor of Mechanical Engineering, Emeritus, Harvard University, Cambridge Mass. Fellow, A.S.M.E.

Books Received in Library

AIRCRAFT NAVIGATION. Part 1: Theory, by H. Stewart and A. Nichols. Part 2: Practice, by S. A. Walling and J. C. Hill. Macmillan Co., New York, N. Y.; University Press, Cambridge, England, 1943. Cloth, 5½ × 8½ in., 146 pp., illus., diagrams, charts, maps, tables, $2. Beginning students of air navigation will find here a concise introduction to the subjects that they must master. Star identification, map reading, position finding, meteorology, and other theoretical matters are explained, and a large number of practical problems provided. The text is the work of British authorities, but has been revised for American use.

AIRCRAFT POWER PLANTS. By A. P. Fraas. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, 6 × 9½ in., 472 pp., illus., diagrams, charts, tables $4.50. The two main parts of this book deal with engine operation and engine installation, with considerable space devoted to fuels and auxiliary equipment. Part III discusses propeller theory and construction. The aim of the book is to present fundamental terms and concepts that will give the reader a good background in all phases of the subject.

AIRPLANE STRUCTURES, Vol. 1. By A. S. Nile and J. S. Newell. Third edition. John Wiley & Sons, New York, N. Y.; Chapman & Hall, London, England, 1943. Cloth, 6 × 9½ in., 454 pp., diagrams, charts, tables, $4.50. Volume 1 of this two-volume set deals with general design procedure and stress analysis with respect to airplane structures. The several chapters cover critical loading conditions, reactions, torsion, beam and truss analysis, joints, connections, and deflections. Illustrative problems are included with each chapter to provide practice in applying the theory involved.

ANALYTIC MECHANICS. By S. D. Chambers in collaboration with V. M. Faires. Macmillan Co., New York, N. Y., 1943. Cloth, 6 × 9½ in., 375 pp., illus., diagrams, tables, $3.75. This book follows in general the basic plan of organization of Chambers' "Mechanics of Engineering" but is a completely rewritten edition. The material has been so arranged that the student begins with elementary material on simple forces and works gradually through friction and moments to the more advanced topics of balancing, impulse, and momentum.

DIE ENGINEERING LAYOUTS AND FORMULAS. By C. W. Hinman. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, 6 × 9 in., 497 pp., illus., diagrams, charts, tables, $5. This volume is intended as a reference book for the tool engineer.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

It attempts to combine the basic principles of assembled die designs with their operating details to give the mathematical formulas that are necessary for laying out the assembled die, and to emphasize a clearly rendered drafting technique. About ninety per cent of the key designs used in tools for presswork are described and illustrated by numerous drawings and photographs.

DRYING AND DEHYDRATION OF FOODS. By H. W. von Loesecke. Reinhold Publishing Corp., New York, N. Y., 1943. Cloth, 6 × 9½ in., 302 pp., illus., diagrams, charts, tables, $4.25. This book, which aims to offer a compilation of the latest practical information on its subject, is the work of one who has had considerable experience in research work on dehydration. It presents a general outline of procedures and practices in commercial use. Types of dehydrators, the dehydration of various classes of foods, plant sanitation, costs, the nutritive value of dried foods, packing, storage, methods of analysis and the reconstitution of dehydrated foods are considered. A glossary and a list of patents are appended.

ELEMENTS OF MECHANICAL VIBRATION. By C. R. Freberg and E. N. Kemler. John Wiley & Sons, New York, N. Y., 1943. Cloth, 5½ × 8½ in., 193 pp., diagrams, charts, tables, cloth, $3. The more elementary phases of vibration are discussed in detail in this book and reduced to a form in which they can be applied to practical problems. The methods of solution presented do not call for a knowledge of advanced mathematics.

ENGINEERING MECHANICS. By F. L. Singer. Harper & Brothers, New York, N. Y., and London, England, 1943. Cloth, 6 × 9½ in., 482 pp., diagrams, charts, tables, $4. A textbook that aims to present the fundamentals of the subject in a manner that will result in thorough understanding and permanent possession of them. Toward this aim, emphasis is centered on a physical understanding of the basic operations rather than on routine rules. Equations are interpreted in terms of their geometrical equivalents, wherever possible. Analytic methods have been emphasized without neglecting graphic ones. Numerous illustrative problems are explained to show the applications of the theory.

(The) ENGINEER'S MANUAL OF ENGLISH. By W. O. Sypherd, A. M. Fountain, and S. Brown. Revised edition. Scott, Foresman and Company, Chicago, Ill., Atlanta, Ga., Dallas, Texas, and New York, N. Y., 1943. Cloth, 5 × 8 in., 503 pp., diagrams, charts, tables, $2.50. This compact volume is intended as a textbook in English composition for students and as a reference book on usage for engineers. The technic that underlies all good writing is presented first, after which the writing of letters, reports, articles, bulletins and specifications is discussed in detail, with numerous examples. The new edition has been thoroughly revised and much improved. It will be found useful by all readers.

(The) FIRST CENTURY OF FLIGHT IN AMERICA, an Introductory Survey. By J. Milbank, Jr. Princeton University Press, Princeton, N. J., 1943. Cloth, 5½ × 9 in., 248 pp., illus., $2.75. Mr. Milbank has provided a readable account of our aeronautical history from the year 1784, when Edward Warren made the first balloon ascension in America, to the eighteen-nineties, when serious interest in heavier-than-air machines began. The careers of prominent aeronauts are described, and there are interesting pictures and a useful bibliography.

FOREMANSHIP TRAINING, compiled and edited by R. B. Starr, foreword by J. I. Yellott. Prentice-Hall, New York, N. Y., 1943. Linen, 5 × 7½ in., 191 pp., diagrams, tables, $2.65. A concise manual in which the fundamental problems of the foreman are discussed in untechnical language by an experienced teacher. The book has been prepared especially to assist new foremen during the current shortage. The course is based on modern practice in leading organizations.

FORMULAS FOR STRESS AND STRAIN. By R. J. Roark. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Cloth, 6 × 9 in., 366 pp., diagrams, charts, tables, $4. Intended as a reference book for designers, this book offers a compact summary of the formulas, facts, and principles relating to strength of materials. Part one treats of definitions and symbols. Part two states general principles, describes methods of stress analysis and the behavior of material under stress. Part 3, which occupies most of the book, discusses the behavior of structural elements under various conditions of loading and gives extensive tables of formulas for the calculation of stress, strain, and strength. Bibliographies accompany the chapters. The new edition has been enlarged.

FUNDAMENTALS OF ENGINEERING DRAWING for Technical Students and Professional Draftsmen. By W. J. Luzadder. Prentice-Hall, Inc., New York, N. Y., 1943. Cloth, 6 × 9½ in., 568 pp., illus., diagrams, charts, tables, $4. The early chapters of this comprehensive work present simple instructions about the necessary equipment and its use, and deal briefly with engineering geometry and the fundamentals of drawing technique. In the later chapters detail work and the making of drawings for various engineering operations and other special purposes are described. A chapter on engineering graphs, charts, and diagrams is included.

HANDBOOK OF PLASTICS. By H. R. Simonds and C. Ellis, assisted by M. H. Bigelow. D-Van Nostrand Co., Inc., New York, N. Y., 1943. Cloth, 6½ × 9½ in., 1082 pp., illus., diagrams, charts, tables, $10. This volume aims to meet a desire for a comprehensive reference work that would treat the details of the subject in one volume. It presents, in nine sections, the fundamental basis and technology of the plastics industry, including the physical and chemical properties of plastics, their production, manufacture, finishing, and applications. Plant practice is included.

(An) INTRODUCTION TO FLUID MECHANICS. By A. H. Jameson. Second edition. Longmans, Green & Co., London, England, New York, N. Y., and Toronto, Canada. 1942. Cloth, 5½ × 9 in., 245 pp., diagrams, charts, tables, $3.40. This brief text has been prepared for use at the University of London, where an elementary knowledge of the subject is required of all engineering graduates. The aim has been to present the subject in a modern way and to illustrate it by diagrams, worked-out examples, and "guided" exercises, and to avoid empirical formulas and tables of coefficients. New material on flow in pipes and notches, and over weirs is included.

SECRETARY TO THE ENGINEER. (Technical Secretary Series.) By Q. Hazelton. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1943. Loose-leaf stiff paper, 5½ × 8 in., 309 pp., diagrams, $1.75. The text provides a course for advanced stenographers who wish training in the vocabulary of engineering, especially that by civil, electrical, chemical, and metallurgical engineers.

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Committee Secretary, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Following is a record of the interpretation of this Committee formulated at the meeting of June 11, 1943, subsequently approved by the Council of the Society.

CASE NO. 999

(Special Ruling)

Inquiry: Is it permissible, under Code requirements, to use material complying with A.S.T.M. Specifications A214-42 for Electric-Resistance Welded Steel Heat Exchanger and Condenser Tubes on the same basis as Specification S-32?

Reply: It is the opinion of the Committee that material complying with A.S.T.M. Specifications A214-42 may be used where provision is made for the use of material complying with Specification S-32.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

A.S.M.E.-A.I.M.E. Joint Fuels Conference Fuels and Coal Divisions

October 28 and 29, 1943, Pittsburgh, Pa.

FOR the past six years each fall the Fuels Division of the A.S.M.E. and the Coal Division of the A.I.M.E. have held joint Fuels Conferences, which, while not unheralded or unsung, have come along quietly and swung into the meetings schedule without much ado. This fall, in Pittsburgh, the seventh of these Conferences will be held on October 28 and 29 at the William Penn Hotel.

Just as a matter of fact these Conferences have produced some of the best fuels papers published by the A.S.M.E. and have sponsored worth-while and valuable round-table discussions where down-to-earth facts are the only ones that have a chance. This is the Conference into which the Fuels Division really throws its effort and for the man interested in this field, it is the meeting he should attend whether or not he is able to attend any others. For it is here he will find men with his own problems, here the papers written for him, and here the good fellowship he enjoys.

Address of Welcome by Harry M. Moses

The meeting will open on Thursday morning, October 28, with an address of welcome by Harry M. Moses, president of the H. C. Frick Coke Company, with the response to be given by Harold V. Coes, president of The American Society of Mechanical Engineers. Immediately thereafter the Conference will get under way with its first technical session on coal research when E. R. Kaiser of Battelle Memorial Institute will talk on "The Progress of Research in Coal Utilization." The second paper, "Test Methods for Rating the Performance of Domestic-Stoker Coals," will be given by R. Helfinstine of the Illinois Geological Survey. The sessions will close with a panel discussion on "Selling Coal Research and Its Product" which will be led by J. E. Tobey of the Upper Monongahela Valley Association.

Luncheon will be served in the Urban Room of the Hotel, and following it H. F. Hebley, member A.S.M.E., of the Pittsburgh Coal Company, will talk on "Australia."

At the afternoon session two papers are to be featured—the first on "Modern Training for the Miners at the Face," by G. R. Spindler of the University of West Virginia, and the second on "Coal Faces Postwar Readjustment" by R. M. Weidenhammer.

Later in the afternoon both Divisions will hold meetings of their respective Executive Committees. There will also be a meeting of the Percy Nicholls Award Committee and still later a joint meeting of the two Executive Committees.

The banquet at the Conference is always a high spot and this one bids fair to more than hold its own. T. E. Purcell, vice-president A.S.M.E., will be the toastmaster on this occasion and will present special guests to the audience. It will also be at this time that the second presentation of the Percy Nicholls Award will be made.

Henry Kreisinger to Receive Percy Nicholls Award

This Award, conferred "for notable scientific or industrial achievement in the field of solid fuels," was established in 1942 to perpetuate the name of Mr. Nicholls who died on February 12 of that year and who from 1925 served as supervising engineer of the Fuels Section of the Bureau of Mines. Mr. Nicholls was the author of more than fifty papers on technical subjects and was an outstanding contributor to the literature of solid fuels. His papers on the fundamentals of combustion were accepted as classics. He was a member of the A.S.M.E. and served on many of its committees. The Award will be presented this year to Henry Kreisinger, member A.S.M.E., manager of the research department, Combustion Engineering Company, Inc., New York, N. Y.

Of particular interest will be the speaker of the evening, General E. P. Sorenson, assistant chief, Army Air Force, Staff Intelligence, War Department, who will take as his subject "Application of Air Power." General Sorenson is an able speaker and there is no question but that his talk will be outstanding.

Trends in Fuels

On Friday the morning session will deal with gas and carbonization, with papers by D. B. Hendryx of the Harbison Walker Company, and by G. C. Soth and C. C. Russell of the Koppers Company on "Sources of Pressure Occurring During the Carbonization of Coal."

At the luncheon session on Friday Cadwallader Evans, Jr., and H. F. Hebley, co-chairmen, will preside while the various committees of the two Divisions will report.

The final session of the Conference will be devoted to the War Program when J. F. Barkley and L. R. Burdick of the U. S. Bureau of Mines and A. B. Hersberger of the Atlantic Refining Company will deliver their paper on "Laboratory and Field Tests on Coal-in-Oil Fuels." The paper will be followed by a panel discussion on Trends in Fuels intended as something in the nature of a grand finale to what is hoped will be the largest Joint Fuels Conference in the history of the Divisions.

Committees

These conferences always mean a lot of good hard spade work for someone and the committees seldom get the real thanks they deserve but at least we can tell you who they are.

A.S.M.E. Executive Committee of Fuels Division

H. F. Hebley, *chairman*
D. C. Weeks, *secretary*
O. F. Campbell
A. W. Thorson
J. E. Tobey

A.I.M.E. Coal Division

Cadwallader Evans, Jr., *chairman*
A. W. Gauger, *vice-chairman*
D. R. Mitchell, *secretary*
N. G. Alford, *past-chairman*

Executive Committee

(Until February, 1944)
Joseph Pursglove, Jr.
Carl G. Stifel
Paul Weir

(Until February, 1945)
A. W. Gauger
Raymond Mancha
T. R. Workman

(Until February, 1946)
Preston H. Haskell, Jr.
L. A. Shipment
H. F. Yancy

Pittsburgh Joint Meeting Committee

T. E. Purcell, Gen. Chairman
H. F. Hebley
T. J. Barry
A. W. Thorson
H. P. Greenwald
L. E. F. Wahrenburg

Committee Chairmen

General Arrangements—T. J. Barry
Programs & Papers—Martin A. Mayers
Inspection Trips—M. R. McConnell
Publicity—T. J. Ryan, Jr.
Hotel & Registration—G. A. Shoemaker

Program

THURSDAY, OCTOBER 28

9:00 a.m.

Registration

(*Program continued on following page*)

THURSDAY (*Continued*)

9:45 a.m.

Welcoming Address by Harry M. Moses, president, H. C. Frick Coke Co.
Response by Harold V. Coes, president A.S.M.E.

10:00 a.m.

Coal Research

Julian E. Tobey, *Chairman*
Sumner B. Ely, *Co-Chairman*
The Progress of Research in Coal Utilization, by E. R. Kaiser, Battelle Memorial Institute
Test Methods for Rating the Performance of Domestic-Stoker Coals, by R. Helfinstine, Illinois Geological Survey
Panel Discussion: Selling Coal Research and Its Product, led by J. E. Tobey, Upper Monongahela Valley Association

12:30 p.m.

Luncheon
Newell G. Alford, *Chairman*
H. F. Hebley, *Speaker*—Subject, Australia

2:00 p.m.

Mining Management

D. L. McElroy, *Chairman*
A. R. Mumford, *Co-Chairman*
Modern Training for the Miners at the Face, by G. R. Spindler, University of West Virginia
Coal Faces Postwar Readjustment, by R. M. Weidenhammer, Cosgrove Coal Co.

4:00 p.m.

Executive Committee Meetings
A.S.M.E. Fuels Division
A.I.M.E. Coal Division

4:30 p.m.

Percy Nicholls Award Committee

5:00 p.m.

Joint Executive Committee Meeting

7:00 p.m.

Banquet
T. E. Purcell—*Toastmaster*

THURSDAY (*Continued*)

Program—Presentation of Special Guests
Presentation of Percy Nicholls Award to Henry Kreisinger, combustion engineer
Speaker, General E. P. Sorenson, Assistant Chief, Army Air Force, Staff Intelligence, War Department, Washington, D. C., on Application of Air Power

FRIDAY, OCTOBER 29

9:30 a.m.

Registration

10:00 a.m.

Gas and Carbonization

H. H. Lowry, *Chairman*
Martin Mayers, *Co-Chairman*
Utilization of Producer Gas in Industrial Furnaces, by D. B. Hendryx, Harbison Walker Company
Sources of Pressure Occurring During the Carbonization of Coal, by G. C. Soth and C. C. Russell, Koppers Co.

12:30 p.m.

Luncheon
Cadwallader Evans and H. F. Hebley, *Co-Chairmen*
Reports of Committees

2:00 p.m.

War Program

W. G. Christy, *Chairman*
J. D. Doherty, *Co-Chairman*
Laboratory and Field Tests on Coal-in-Oil Fuels, by J. F. Barkley, U. S. Bureau of Mines; A. B. Hersberger, Atlantic Refining Company; and L. R. Burdick, U. S. Bureau of Mines
Panel Discussion—"Trends in Fuels"

NOTE: A meeting of the A.S.M.E. Fuels Division Committee on "A Model Smoke Law" with an A.S.T.M. Subcommittee on "Coal Sampling for Volatile-Matter Determination" of Subcommittee XIII of Committee D-5 on Coal and Coke has been arranged for Wednesday evening, October 27, 1943, at 7:30 p.m. in parlors B and C.

A.S.M.E. to Organize Design Group

AT its 1943 Annual Meeting to be held in New York, Nov. 29–Dec. 3, The American Society of Mechanical Engineers proposes to organize a "Design Group."

For many years, some members of the Society have felt that a very important function of mechanical engineering, namely, design, was not adequately represented in its activities and they have urged the creation of a "Design Division." There existed a group dealing with machine design. This was an activity of the Machine Shop Practice Division and was represented by a Subcommittee on Machine Design. This subcommittee has proved for the last four years by the well-attended meetings it has prepared that a design group can have a well-deserved existence.

The Machine Shop Practice Division was reorganized as the "Production Engineering Division" about two years ago. Meetings on design have continued and it has been demonstrated that the subject has vitality.

A certain important percentage of the membership, particularly of the younger engineers, are primarily interested in design, and this part of the membership is now encouraged to organize so as to advance this activity in which they are interested.

Design is a very important function of all engineering and particularly of mechanical engineering. This has been demonstrated especially in the present national emergency, and it is certain that in the future, after the termination of the war, design will become still more important on account of extreme world competition.

The A.S.M.E. Committee on Professional Divisions has decided to go ahead with the formation of a Design Group which, with sufficient support by the membership, will be expanded into a Design Division. Such a group would form a cross section through the Society's activities and work in conjunction with the various divisions now existing. The new Design Group will organize meetings in conjunction with these various divisions for the discussion of their products from the angle of design or, in other words, will deal with the design features of the entire field of mechanical engineering.

It is the intention of the A.S.M.E. to organize such a Design Group at the forthcoming Annual Meeting in New York at the end of November. A full day's session on design is being prepared in which interesting papers will be presented and, at a special meeting, the Design Group will be organized. All designing engineers, designers, and draftsmen who are interested in joining this new Design Group are cordially invited to attend this meeting and the sessions on design which are scheduled for Friday, December 3. Anyone who wishes to join this new Design Group, but is unable to attend the inaugural meeting, may do so by signing a card which may be obtained on request to Headquarters of the Society. It is hoped that all designing engineers, designers, and draftsmen will avail themselves of the opportunity of becoming members of the new Design Group, and thereby advance their interests. Lively sessions on design will benefit all concerned. Members are urged to attend the inaugural meeting of the Design Group and to bring their friends and associates. No extra fees for joining this new group.

1944 A.S.M.E. Mechanical Catalog and Directory Out

Over 600 Pages of Information

THE thirty-third annual A.S.M.E. Mechanical Catalog and Directory, 1944 edition, to be published October 1 by The American Society of Mechanical Engineers, will be distributed to A.S.M.E. members during October.

In its catalog section, manufacturers describe and illustrate their products that are of interest to mechanical engineers. This section is followed by a Directory which gives the user a practically complete and authoritative index to manufacturers of metals and alloys, power-plant equipment, power-transmission equipment, instruments, materials-handling apparatus, aircraft power plants and instruments, foundry and machine-shop equipment, heating, ventilating, and air-conditioning equipment, electric motors and controls, equipment for process industries, pumps, fans, compressors, and many other types of mechanical apparatus. A page-reference system in the Directory ties up with the catalog, providing descriptions of the desired machine or equipment.

According to the editors of the volume, it is the only book which covers the field of mechanical engineering so thoroughly.

A 16-page insert describing all A.S.M.E. publications, such as power test, boiler construction, and safety codes, American Standards, fluid meters, engineering biographies, bibliographies, research reports, and manuals, is included in this volume for the ready reference of A.S.M.E. members and other users.

E.I.C. to Meet in Quebec, Feb. 10 and 11, 1944

THE Engineering Institute of Canada has announced that its 1944 annual meeting will be held in Quebec City, at the Chateau Frontenac, February 10 and 11, 1944.

The A.S.M.E. 1943 Annual Meeting, November 29–December 3, to Break All Records

ADVANCE plans for the 1943 Annual Meeting of The American Society of Mechanical Engineers to be held in New York, N. Y., November 29–December 3, give every indication that it will break all previous records both in attendance and in the number and scope of its sessions.

With this thought in mind the Committee on Meetings and Program has selected the Pennsylvania Hotel for the headquarters where it will be possible to handle more completely so large a convention.

Starts on Sunday

While the technical sessions do not get under way before Monday, the Meeting very definitely starts on Sunday, November 28. On that morning the Executive Committee of the Council meets and the Conference of the Local Sections Delegates, always an important part of every Annual Meeting, will start its work.

Members of the Council and the Delegates will have luncheon together and in the afternoon the Sections Conference will continue while the Council convenes in formal session.

After dinner the evening will be devoted to a general meeting of members of the Council with representatives of the A.S.M.E. Professional Divisions, the various Committees, and the Local Sections.

Headliners at Monday's Luncheon

Last year saw the innovation of luncheon on Monday which officially launched the technical sessions of the week. There was a magnificent turnout for that event and it is planned now to outdo it this year. Speakers at the luncheon will include Charles F. Kettering and Vannevar Bush—names to conjure with in the engineering field.

There has been no announcement of the topics on which these men will speak but any one who knows either of them knows also what each will talk about will be something of greatest interest at the moment. Both men have reputations of being worth listening to regardless of subject matter and whatever they talk about is always the thing that people want to hear, so if you plan to attend the luncheon it is not too early to make your reservation immediately. Last year hundreds were turned away from the Sikorsky luncheon, and although accommodations will be better this year we can promise you definitely that you won't be in on this treat if you don't manage to let us know your plans well in advance.

The official Business Meeting of the Society will follow this luncheon and will start at 4:00 p.m.

Technicalities

Present indications point to fifty-four technical sessions but that is no guarantee that by next month there won't be twenty more as practically each day comes word that some new session is imperative in this year of war. All of the sessions are geared to war, with papers bearing directly on subjects of vital concern.

Sessions have been requested on applied mechanics, aviation, fuels, heat transfer, hydraulics, industrial instruments, management (work standardization, quality control, post-war planning, management in the Federal Government, farm simplification), metals engineering, oil and gas power, power, production engineering, railroad engineering, rubber and plastics, textiles, wood industries, education and training, metal cutting, plastic flow of metals, furnace performance, mechanical springs, boiler feedwater, critical-pressure steam boilers—well, just pick yourself anything you are interested in that might come under the head of mechanical engineering—it will be there.

THE PENNSYLVANIA HOTEL

The layout of the time and place of these sessions will appear in an announcement to be sent to members around November 1. The complete technical program will also be published in the November issue of MECHANICAL ENGINEERING.

Enemy Patents

Plans have already been started to provide space for an exhibit of some thirty-five thousand mechanical and electrical patents of enemy countries which have been seized by the Alien Property Custodian. A similar exhibit at the Los Angeles Semi-Annual Meeting aroused great interest.

More Luncheons

There will be a "Management" Luncheon on Tuesday which those in charge of it hope will be attended by as many as can possibly make it as a compliment to our "Management President," Mr. Coes. On Wednesday in addition to the usual Student Luncheon there will be one conducted by the Aviation Division. On Thursday both the Railroad and Textile Divisions have luncheons scheduled.

Make Your Reservations Now!

The Pennsylvania is a big hotel but don't bank on that fact if you expect to stay there for the Meeting—get your reservation in now and you won't be disappointed or running all around town at the last minute trying to find a place. New York has lots of hotels but it also has lots of visitors—so sit down now and make your reservations directly with the hotel for your room and with us for special luncheons and the banquet. And wait till you hear about the banquet—a little later. It will please you very much.

Official Notice A.S.M.E. Business Meeting

THE Annual Business Meeting of the members of The American Society of Mechanical Engineers will be held on Monday afternoon, November 29, 1943, at 4:00 p.m. at the Pennsylvania Hotel, New York, N. Y., as a part of the Annual Meeting of the Society.

Registration Fee for Non-Members at the 1943 Annual Meeting

There will be a registration fee of $2 for nonmembers attending the 1943 Annual Meeting. For nonmembers wishing to attend just one session (except evening sessions or meal meetings) the fee will be $1. This is in accordance with the ruling of the Standing Committee on Meetings and Program.

Members wishing to bring nonmember guests (male) may avoid this fee by writing to the Secretary of the Society before November 22 asking for a guest-attendance card for the Annual Meeting. The card, upon presentation by a guest, will be accepted in lieu of the registration fee. Guests are limited to *two per member*.

Army Air Forces Need Inspectors

THE Matériel Command of the Army Air Forces is in need of additional inspectors to be assigned to airplane, engine, propeller, and instrument plants in the Eastern Procurement District, which includes the New England States and the states of New York, Pennsylvania, New Jersey, Delaware, and Maryland.

Men over 37 years of age or men under 38, who have dependent children, and are of fine character and patriotism, are particularly desired. Technical training and some mechanical experience are desirable but not absolutely necessary.

An A.A.F. Inspector's School is maintained in New York where all inspectors are trained before being assigned to contractors' plants.

Inquiries should be addressed to Lieut. Colonel W. S. Johnston, District Inspection Officer, Eastern Procurement District, Matériel Command, Army Air Forces, 67 Broad Street, New York, N. Y.

President's Page

Co-Ordination of the Engineering Profession

AS a result of conversations with officers and members of the Local Sections thus far visited, I have been impressed with the interest, almost universally expressed, in the problem of co-ordination of the profession. This interest was not confined to any region or to any age levels of the groups visited. I am, however, under the impression that more interest was evinced by the younger than the older members.

Talking with Dr. Osborne, past-president of the A.I.E.E., I discovered that his experience with respect to this subject paralleled mine.

The questions most frequently asked of both of us were: "What is being done to bring about co-ordination in the engineering profession?" and, "What is our Society doing about it?"

Analyzing the interest expressed in this subject I came to the conclusion that it arose from a consciousness that the old well defined lines of differentiation between the various segments of the profession are now somewhat hazy in many respects or, as a matter of fact, have in some instances almost disappeared. Furthermore there is a deep-rooted feeling that the profession cannot speak with authority and unity on matters of common fundamental interest as does the American Medical Association or the Bar Association or the Institute of Architects. Many members think that as a result of the lack of a unified front the engineering profession suffers in prestige and in broad usefulness.

Many say, quite correctly, that the public thinks of the engineering profession as a whole, not in classifications, such as Civil, Mining, Electrical, Mechanical, Automotive, etc. They are concerned over the fact that they sense a waning of influence of the profession as a whole and are deeply perturbed by it.

I promised my interrogators that I would do something about this matter. I am now able to report to you, through this medium, that the Joint Conference Committee of Presidents and Secretaries of the A.S.C.E., A.I.E.E., A.I.M.E., A.I.Ch.E., and A.S.M.E. have appointed a committee composed of Dr. Mathewson, President of the A.I.M.E., Major Whitman, President of the A.S.C.E., and Mr. Funk, President of the A.I.E.E., chairman, to outline and define the problem and to plan, in true engineering fashion, the approaches to solutions of the problem. After the Joint Conference Committee receives this report it will ask each participating society to appoint representatives to a working committee that will work out the solutions. Probably representatives of various other segments of the engineering profession will be invited by the Joint Conference Committee also to appoint representatives on the large committee in order to have fairly complete representation of the engineering profession as a whole.

I desire to point out that alternative solutions of this important problem will not be forthcoming in a month, or in fact several months. So we must be patient and give the committee time and our full, sympathetic, and understanding support.

I am sure Mr. Funk's committee will welcome any concrete suggestions and ideas you may have on the subject. Simply address your communications to the Secretary of the Society and they will be transmitted to Mr. Funk.

(*Signed*) HAROLD V. COES, *President, A.S.M.E.*

Chairman, Joint Conference Committee of Presidents and Secretaries

With the Student Branches

Many Student Papers and "Accelerated Christmas Party" at Cooper Union

On August 3 the Cooper Union (Day) Branch met to hear Solomon Musicant, student, deliver his paper on "Photoelastic Stress Analysis." As polarized light is the means of observing the reactions of members under stress, Mr. Musicant first explained this topic to facilitate understanding the technique of photoelastic stress analysis. It was pointed out that a model of the member to be examined is first made of a transparent material, such as bakelite. Under the action of stresses this material becomes doubly refracting, and if a beam of polarized light is passed through it, a picture with dark and light bands and fringes is obtained, indicating points of localized stress. Numerous photos were exhibited as well as an actual demonstration with polaroid sheets for polarizer and analyzer.

Fatigue Stresses

This Branch met again on August 10 and heard Leon Resnicow, senior mechanical-engineering student present the sixth of a series of student papers. The subject was "Fatigue Stresses." Mr. Resnicow explained that the phenomenon of decreased resistance of a material due to cyclic stress is called fatigue. After it was described how a piece of material ruptures from fatigue stresses, a few samples of test pieces were examined by those present. With the aid of projected photos and curves, he gave the principal causes of fatigue failure.

On August 17 this Branch met again to hear the seventh in a series of student papers. Burton Edelstein, junior mechanical-engineering student, lectured on "Temperature Measurement and Control." After describing many types of temperature-measuring devices, Mr. Edelstein gave a detailed description of pressure-gage thermometers. These usually contain nitrogen as the expanding substance, as it has a low specific heat and a high coefficient of expansion. Vapors are also used in this type of thermometer, the two important ones being methyl chloride and sulphur dioxide. With the aid of slides the various details of the instruments were discussed, together with temperature control. Then the meeting was opened for questions.

Cooling of Aircraft Engines

On August 20 this Branch met to hear the last in a series of student papers given by Edward Blum on "Cooling of Aircraft Engines." It was explained that the need for cooling is threefold: (1) to maintain a lubricant film on the walls; (2) cylinder heads, pistons, and exhaust valves are cooled to prevent deterioration and to keep these parts from failing due to excess heat; (3) to increase the volumetric efficiency of the engine. It was pointed out by Mr. Blum that the two principal methods for cooling are by the use of air or liquid. With the aid of slides, Mr. Blum showed how fins are used to increase the outside area of the cylinder.

On August 21 the Branch held its twenty-first annual "accelerated Christmas Dinner," followed with speeches by Dean G. F. Bateman, Prof. H. F. Roemmele, Prof. Wm. A. Vopat, Prof. K. E. Lofgren, and Professor Heil. Professor Vopat announced the winners of the student-paper contest held this past year. The first prize was awarded Leon Resnicow for his paper on "Fatigue Stresses," and the second prize went to Burton Edelstein, for his paper on "Temperature Measurement and control." As the senior mechanical-engineering students were to be graduated the following week their spirits were high, and the usual giving of Christmas presents to the faculty by Mr. Resnicow brought many chuckles. No doubt the most novel event of the evening was having the alumni describe their "doings" and whereabouts since graduation. After the meeting most of the members went bowling.

Other Branch Meetings

Akron Branch held its meeting on August 18 when it heard L. E. Soderquist, chief engineer of the McNeil Machine and Engineering Company, explain some of the latest developments of toggle-link mechanisms in connection with tire presses.

On August 4 California Branch held its first meeting of the term to elect a vice-chairman and senior and junior representatives to the Engineers' Council. Considerable enthusiasm was exhibited by all members in the voting. The result of the election follows: Robert Lockhart, senior representative; John Jakosky, junior representative; and William Bulen, vice-chairman. Lieut. Comm. Vogt gave an interesting talk on Navy Diesel schools and related subjects.

Dad's Night at Case Institute

The Case Branch met on May 19, which was another in its series of "Dad's Night" meetings. J. M. Roth of Pump Engineering Service Company, spoke on the "Design and Use of Various Types of Pumps." Another meeting was held on July 28 to hear Matthew A. Payne, formerly with the propeller unit, production engineering section, Wright Field, Dayton, Ohio, discuss "Modern Aircraft Propellers." He discussed aerodynamics and operational theories, blade stresses, dual rotation, and propeller trends. Following the lecture an N.A.C.A. film entitled "Safe Flying," was shown. The film covered such subjects as smoke tests, float tests, propeller noise, and deicing tests. New officers were elected as follows: W. C. Roberts, honorary chairman; R. H. Bridges, chairman; J. R. Jeromson, vice-chairman; T. Kobara, secretary, and L. Epstein, treasurer.

Colorado State Branch met on July 20 for the purpose of organizing and electing officers for the ensuing year. The following officers were elected: Prof. J. H. Scofield, honorary chairman; Robert C. Hutchinson, chairman; Robert C. Ruhl, vice-chairman; H. Merle Jessup, secretary; Basil C. Larcher, treasurer; Temple S. Rowe, program chairman. Although Professor Scofield has finished serving as honorary chairman the usual period of three years, it was deemed advisable to ask him to serve until December 20, 1943, the close of the present accelerated year. The prospects for continuing an active Student Branch at this college beyond that date seem

A.S.M.E. STUDENT CONFERENCE GROUP XIX, APRIL 10, 1943, NEW MEXICO STATE COLLEGE, NEW MEXICO

PRESIDENT COES PRESENTING FIRST PRIZE TO LAWRENCE LIEF, WINNER OF THE TECHNICAL PAPER COMPETITION AT THE A.S.M.E. STUDENT CONFERENCE HELD ON APRIL 17, 1943, AT THE COLLEGE OF THE CITY OF NEW YORK, NEW YORK, N. Y., GROUP III

very unlikely. After that date the school will be composed chiefly of Army students.

DREXEL BRANCH held its second meeting of the term on July 29, at which plans were discussed for a mechanical-engineers' outing in the fall. The results of a program survey were announced. The first five topics of interest in order of selection were, "Aeronautics," "Diesel Engineering," "Automotive Mechanics," "Management and Production," and "Metallurgy." All mechanical engineers in the school took part in the survey. The topic of this meeting was "Automobile Design and Construction." Prof. A. H. Repscha, member A.S.M.E., of the mechanical-engineering department was the speaker.

Trip to Modern Office Building

This Branch met again on August 19. Roland Minshall, inspection-trip-committee chairman, reviewed the trip of August 7 to the P.S.F.S. office building in Philadelphia, Pa. Thirty members made a tour of a modern building. They inspected the power plant, electrical apparatus, elevator machinery, and air-conditioning units. The acting president, Arthur Watkins, was nominated for president of the Branch and unanimously elected president for the 1943–1944 school year. Lester Stradling, of the mechanical-engineering department, spoke on "Aircraft Flight Instruments," an illustrated talk, which included a demonstration of gyroscopic action as it applies to aircraft instruments. He described the principle of the altimeter, speedometer, and other flight instruments, using real instruments for explanation.

DUKE BRANCH held its first meeting of the semester on August 3 at which former members at different colleges who are now enrolled at this university under Navy and Marine programs were heartily welcomed and urged to continue their membership in the A.S.M.E. Prof. E. S. Theiss, member A.S.M.E., honorary chairman, discussed how it was planned to have the Branch function during the new speed-up programs. Officers for the following semester are: Carl Metz, president; Joe Myers, vice-president; George Beer, secretary; and George Yautz, treasurer. Professor Theiss will act as honorary chairman.

This Branch held another meeting on August 17 to hear an interesting talk by Mr. Cooke, an instructor in the mechanical-engineering department. He spoke on "An Outside Steam-Distribution Job." He explained some of the obstacles that were met while on the job and how these obstacles were overcome. Mr. Andrews, a former member of the Branch, who is now employed by Pratt and Whitney Aircraft Engine Company, was also at the meeting and spoke about his present work at this concern.

The summer session of the GEORGE WASHINGTON BRANCH consisted of three meetings. On July 7 a discussion of Merchant Marine Service including entrance requirements was held, led by a representative of the United States Merchant Marine. On August 4 two films were shown on "Machining Operations," by Prof. B. C. Cruickshanks, member A.S.M.E. On September 1 a lecture was given by a student, Julius Ritter, on "Welding Symbols." This talk won a prize at an A.S.M.E. Student Convention in 1942 at Penn State University. New officers were elected at this meeting.

Professor Yellott Talks at Illinois Tech

The first summer semester meeting of the ILLINOIS TECHNOLOGY BRANCH was held on July 23 when Prof. J. I. Yellott explained that the student branches are the principal source of the parent organization, and that the A.S.M.E. is a means of establishing the professional standing of the engineer.

IOWA STATE BRANCH held an informal smoker for the recently arrived V-12 Naval Reserve men and new students. William Galloway introduced the officers of the Student Branch and was master of ceremonies. President Perelman gave a brief talk urging men who were not members to become members as soon as possible. President David L. Arm, member A.S.M.E., spoke on the benefits derived from being a member of the A.S.M.E. On July 28 this Branch met to discuss and nominate candidates for honorary chairman. Prof. C. T. Grace, member A.S.M.E., was elected.

The LOUISIANA BRANCH held its last meeting of the summer session on August 18. Election of officers for the coming quarter was the main business of the meeting. At the close of the meeting the two outgoing officers, E. E. Connor, former president, and R. O. Laird, former treasurer, were given a vote of thanks for their services by the entire Branch.

The MARYLAND BRANCH held its monthly meeting on May 5 when it was announced that the Eichlin Memorial was presented at the O.D.K. tapping ceremonies. Oscar Swecker gave an illustrated talk on "Photoelastic Stress Analysis." An Allis-Chalmers film, on "Steam Turbines" was shown. This Branch met again on July 28 to elect new of-

A.S.M.E. STUDENT CONFERENCE GROUP II APRIL 9, 1943, HELD AT SYRACUSE UNIVERSITY, SYRACUSE, N. Y. PICTURE TAKEN IN AIR-CONDITIONING LABORATORY AT THE UNIVERSITY

ficers. A discussion was held on plans for the coming term and a swimming party for August 13 at the Greenbelt Park was planned. The film, "Oil for Aladdin's Lamp," produced by the Shell Oil Company, Inc., was then shown.

Officers of the M.I.T. BRANCH met on August 16 to discuss (1) publicity and means for attracting the attention of the students to the A.S.M.E. in order to increase the membership; (2) activities for the coming term, including meetings, dinners, speakers, plant trips, dances, and picnics.

On August 16 the MICHIGAN MINING AND TECHNOLOGY BRANCH held its first meeting. The first business was election of new officers. Prof. A. P. Young, honorary chairman, presided and then read an article on "Unionization of Engineers." On August 19, this Branch again met and heard Professor Young discuss the purposes and privileges of the A.S.M.E. Ralph Launier gave a brief résumé of "Social Security Progress" and George Ishida spoke on "Relationships Between the Engineers and Unions." Short discussions followed both talks.

On August 26 this Branch again heard Prof. A. P. Young outline the program followed by the A.S.M.E. last year so as to give the new members some idea of its activities. An interesting lecture was given by Alton Roth on his experiences in industry. This talk emphasized the jobs held in New York and New Jersey in such plants as Western Electric Co., Inc., and Sterling Engine Co.

MICHIGAN STATE BRANCH held its last meeting of the summer session on August 12. This was a joint meeting of the four engineering societies on the campus. After a short business meeting, three films of a technical nature and one on the current war were shown.

A Picnic at Missouri Branch

The MISSOURI BRANCH enjoyed a picnic on August 14 which was sponsored by the local A.S.M.E. Branch and members of the mechanical-engineering faculty. The feature of the afternoon was a soft-ball game in which the challenging civilians defeated the A.S.T.P. 9 to 1. In attendance at the picnic were 21 A.S.T.P. students, 28 civilian students, and 8 faculty members. Visitors present were Dean H. A. Curtis, of the College of Engineering, and Col. A. McIntyre, commanding officer of the A.S.T.P. and R.O.T.C. units at Columbia, Missouri. On August 24 this Branch met and saw the film "Zinc-Alloy Die Casting" produced by the New Jersey Zinc Company. Following the film an election was held in which Robert L. Toal was elected to replace the former treasurer.

Northeastern Branch Hears Many Interesting Papers

NORTHEASTERN BRANCH held the first meeting of the division "B" section on July 12. Election of officers was held and the following were elected for this term: Lewis Bacon, chairman; James Connors, vice-chairman; Ralph Buck, secretary; Joseph Profitor, treasurer. On July 20 this Branch held another meeting to discuss plans for future meetings and programs. A student, Edward Burger, gave a talk on "Tool Design," emphasizing one phase of the design of a jig.

This Branch held its third meeting of the division "B" section on August 12. Paul Mayo, a student, spoke on "Engine-Oil Deterioration and Filtration," his information being based on his co-operative work experience. He described in detail the causes of engine-oil deterioration, and he illustrated his points with blackboard sketches. This Branch held its fourth meeting of the "B" section on August 19 when it was announced that a smoker would be held on August 27. Edward Carpenter spoke on "Distilling Plants on Warships," basing his talk on his co-operative experience at the Fore River Shipyard. The talk was illustrated by a sketch of a complete distilling plant showing the routes of the fluid mediums.

War Department Film at Ohio State

On June 5 the OHIO BRANCH held their first summer quarter meeting. Dean C. E. MacQuigg gave an informative talk on the engineering students' position concerning selective service and discussed the A.S.T.P. program. The second summer meeting of this Branch was held on July 9 when a War Department training film, "Physiology of High-Altitude Flying" was shown.

The third summer meeting of the Ohio Branch was held on July 23. Mr. Marco explained new membership regulations and a film on "Zinc Die Casting," produced by the New Jersey Zinc Company, was then shown. On August 6 the Branch held its fourth summer meeting to see the Army training Film, "Aircraft Engines." A special election meeting was held on August 13 and the following officers elected for the next quarter; John F. Hall, chairman; Lawrence Deneroff, vice-chairman; William E. Irwin, secretary; and Preston R. Crabell, treasurer.

At a meeting on March 29 the PENN STATE BRANCH with 150 members and guests present welcomed incoming freshmen. A film, "The Production of Glass," was shown. On April 7 this Branch heard Fred Rohm of the Aviation Corporation, Lycoming Division, Williamsport, Pa., speak on problems confronting an experimental engineer in the production of a light air-cooled aircraft engine. On July 29 this Branch met again, when the new president outlined a proposed program for the coming months. Films were shown on manufacture and testing of Diesel locomotives. On August 2 the Branch held another meeting devoted to the incoming freshmen. The film "Building a Bomber" was shown.

U. of P. Hears Helicopter Principles

On August 23 an audience of 300 students and townspeople enjoyed a lecture and film on the helicopter presented by the UNIVERSITY OF PENNSYLVANIA BRANCH. Albert Yackle, president of the Branch, sketched the life of the inventor Igor Sikorsky before presenting Boris Osijnak, a senior in aeronautical engineering. Mr. Osijnak, supplementing the aerodynamics film with explanations, described the principles behind the helicopter and pointed out that the safety feature of the airplane is that of constant speed, reducing the possibility of stalling to an impossibility. A second film presented was a technicolor movie showing one of the first helicopters in the various stages of flight. Charles Duke, an aeronautical-engineering senior, described the future helicopter as an airplane traveling at more than 80 miles per hour, and costing no more than the average modern automobile. Credit for this successful meeting should be accorded Prof. John W. Oehrli, who did much toward its planning.

This Branch met again on August 25 and heard James Davies, manager of the marine-engineering department of the Westinghouse Electric & Manufacturing Company, speak on "New Developments of High Pressure and Temperature Steam Units Used for the Propulsion of Modern Naval Vessels." The topic was of special interest to many members of the school who will enter the Navy upon graduation. Accompanying Mr. Davies on his visit were Messrs. O. B. Agnes and Lee Bennett of the Westinghouse Company. Lieutenant Hopkins and Lieutenant Nelson of the Naval R.O.T.C. unit also attended the meeting.

Creep and Fatique at Pratt

PRATT INSTITUTE at its first meeting of the summer semester on August 17 heard Charles Kishibay, a senior mechanical-engineering student, present a paper on "Creep and Fatigue". A lively discussion followed.

PURDUE BRANCH held its last meeting for the current semester on August 11. Prof. W. T. Miller spoke on the topic, "Moisture

AT A.S.M.E. STUDENT CONFERENCE MAY 7, 1943, UNIVERSITY OF MARYLAND, GROUP V

(*Left to right:* Martin Johnson, Old Guard Prize Winner; Max Kerschensteiner, second prize; E. C. Kilgore, first prize; Faith Halpine, toastmistress; Prof. A. G. Christie Past-President, A.S.M.E., one of the judges at the Conference.)

Condensation in Walls." His discussion, which was accompanied by an illustrative motion picture, considered the problems incurred by moisture condensation and suggested several methods by which such troubles can be cured. New officers are as follows: Bob Gallatin, chairman; Dan Pliske, J. W. Swantz, Hans Wormser, and Fred Hohenstein, vice-chairmen; Mischa Schocken, secretary-treasurer; Prof. R. W. Leutwiler, member A.S.M.E., honorary chairman. The retiring chairman, Dave Badger, was presented with a book entitled "Autobiography of an Engineer," in appreciation of his services rendered.

RICE BRANCH met on August 4 and took a poll to determine the wishes of the members in regard to prospective speakers, entertainment, and programs. A motion was passed re-electing J. B. T. Downs, honorary chairman. This Branch met again on August 18 to hear Eugene Heyck, Branch secretary, give details on site selection, plant layout and works, and the problems included in its construction.

Rutgers Holds Reorganization Meeting

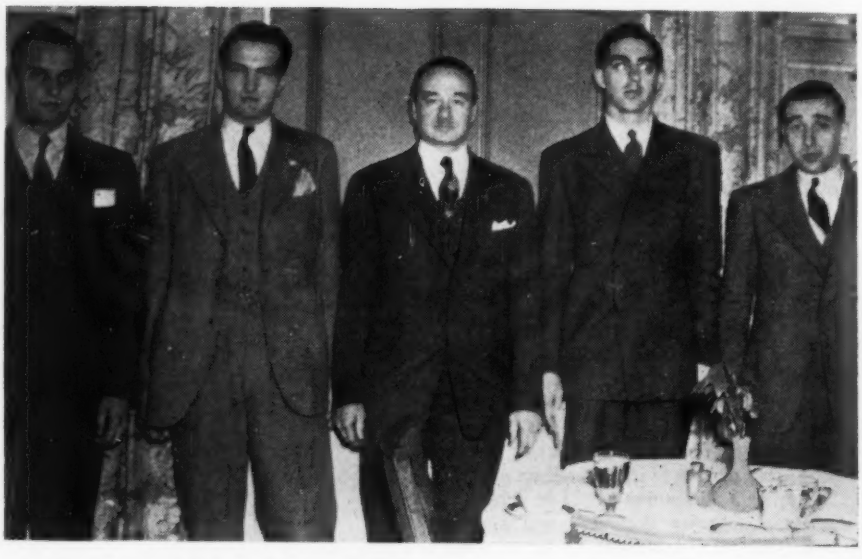
RUTGERS BRANCH held its first meeting of the summer term on July 29, which was primarily concerned with reorganization details and the introduction of new men (freshmen and A.S.T.P. men) to the functions of the A.S.M.E. A program committee of four was chosen; J. E. West, chairman; J. H. Gaston, chairman of publicity committee. As the vice-chairman, Charles P. Longo, has entered the service, the chairman advised the members to consider possible candidates for election at the next meeting.

On August 5 the TENNESSEE BRANCH met to hear William Garrity, a student, give a talk on "The Gas Turbine." Mr. Garrity outlined the origin and development of the gas turbine together with its construction and functions. An interesting film, "Wheels Across India," by the Chrysler Corporation, was shown.

Washington University Sessions

On June 30, WASHINGTON UNIVERSITY, St. Louis, Mo., met and discussed plans for a picnic and the next social event, which was to be a boat ride in the new streamlined *Admiral*. On July 7 the Branch met again to discuss picnic plans to be held at Spring Lake. They held another meeting on July 14 when it was planned to have a swimming and bowling party for the members. There was discussion of technical talks to be given by the members, and it was decided that members should start their preparation as soon as possible. On August 4 a talk on "Modern Use for the Gas Turbine," was delivered, and at a meeting on August 11 this Branch met to hear Paul Neuhoff explain the new six- and twelve-month membership terms.

The WEST VIRGINIA BRANCH held three meetings during the month of July. At these meetings papers were delivered as follows: "Wind Power," R. Jenkins; "Rocket Planes," W. McCoy; "Steel Production," J. Wargacki; "Yes, a Problem for the Engineer," R. Hewitt; "Construction of a Muzzle-Loading Rifle," W. Judy; "Future Air-Transport System," Olsen; "Precision Gages From Glass," R. Fisher, and "Organization of a Construction Company," J. Nunley.



WINNERS AT GROUP XI A.S.M.E. STUDENT CONFERENCE HELD AT NORTHWESTERN UNIVERSITY, EVANSTON, ILLINOIS, APRIL, 12-13, 1943

(*Left to right:* K. L. Pennau, S. Lomezis, T. S. McEwan, district manager, Defense Contract Service, Office of Production Management, who awarded prizes; John Baker, and Bernard Hattis.)

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. When making application for a position include six cents in stamps for forwarding application to the employer and for returning when necessary. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

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MEN AVAILABLE

ENGINEER OR CONSULTANT on electric motors. Lifetime experience in motor manufacture, fractional hp to 8000, in shops employing 500 men or less. Successful in clearing production jams, applying incentive payment, substituting for difficult or expensive materials, preparing bills of material to suit shop conditions. Available part time if desired. Outside service age. Want share in war effort. Me-813.

SALES ENGINEER, graduate standard technical school, with actual shop experience, plus 15 years' specialty selling, desires permanent connection with manufacturer of small tools or kindred items. Southeast. Me-814.

MECHANICAL ENGINEER, 27. Offset printing and internal-combustion engine-test development experience. Desires engine and engine-accessories testing and development work. Prefer New York, N. Y., or vicnity but willing to travel. Me-815.

POSITIONS AVAILABLE

ENGINEERS. (*a*) Chief development engineer for company manufacturing electromechanical devices. Must be able to direct laboratory and design in the promotion of new products. Must be thoroughly experienced and have some experience on electronic circuits as well as serve applications. (*b*) Development engineers to work on board. Must have some experience on small electromechanical devices, such as instruments. (*c*) Manufacturing engineer to assume full responsibility for design, production, estimating methods of manufacture, etc., in connection with machine-shop and sheet-metal plant. (*d*) Estimator for machine-shop and sheet-metal plant. Must have some previous experience and be able to work from blueprints. (*e*) Estimator for electrical production shop. Must be able to take quantities from circuit diagrams. $5000–$10,000 a year. Permanent. New York, N. Y. W-2634.

(*A.S.M.E. News continued on page 758*)

NO. 9 OF A SERIES
HOW TUBE-TURN WELDING FITTINGS BENEFIT WAR INDUSTRY

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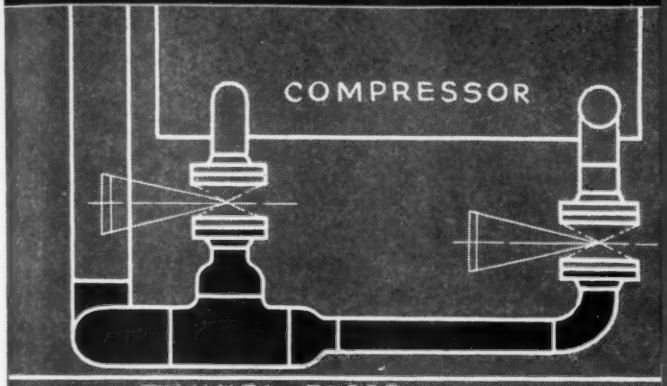
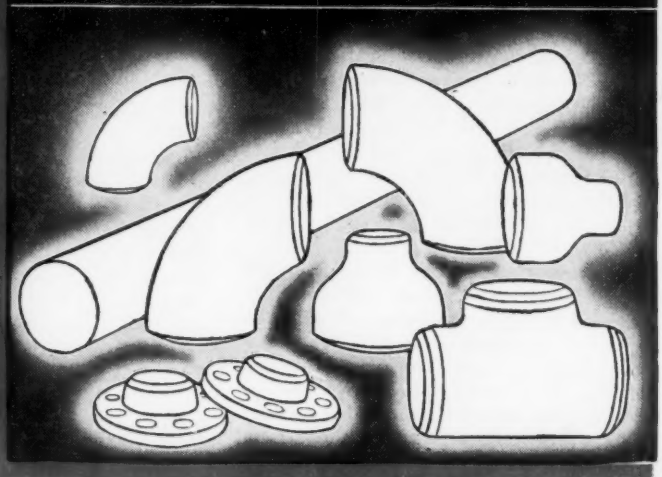
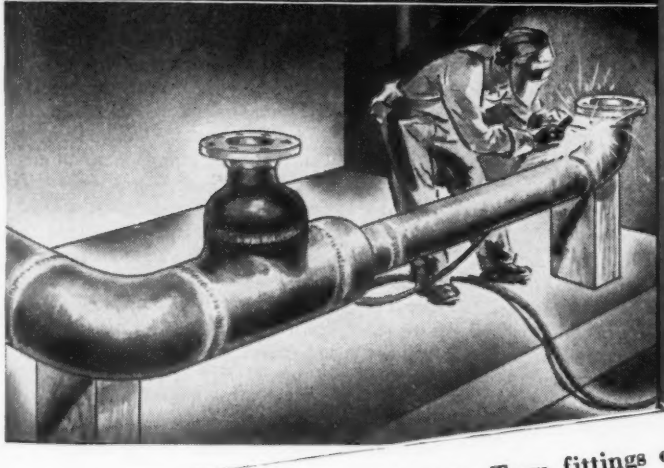
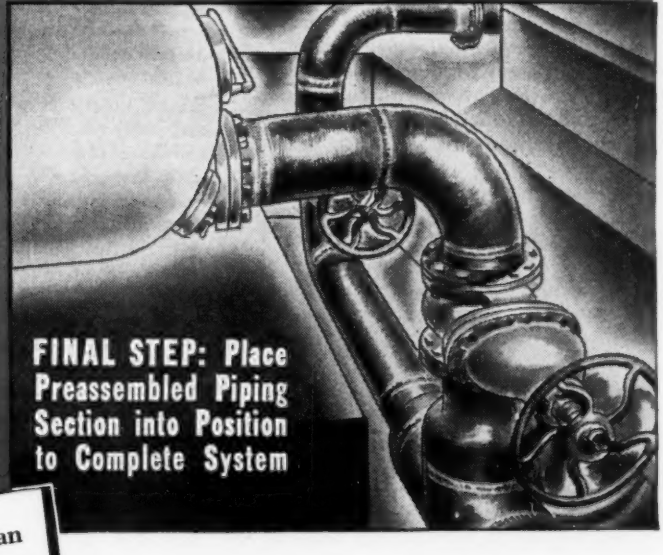


1st STEP: Assemble Pipe and Tube-Turn Fittings



2nd STEP: Preassemble Section in the Shop





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FACTORY MANAGER, sound executive and organizer, for medium-sized plant normally producing metal parts for motor industry, now engaged in the manufacture of war materials. Should be experienced with record of achievement. Permanent. Michigan. W-2640-D-1582.

MECHANICAL DESIGNER to work on design of hoists, cranes, elevators, winches, etc. Must have the vision which is necessary for original designs. Salary open. New York, N. Y. W-2642.

DRAFTSMAN, mechanical engineer, with experience in piping drafting. Should also be good material take-off man for marine work. Salary in neighborhood of $4732 year. Florida. W-2652.

SUPERINTENDENT for modern plate and tank shop. Should be experienced and capable of planning production, with full knowledge of production cost and experience in handling men. Must be draft-exempt and able to accept position immediately. Apply by letter giving complete information and including names of at least three references. Location, Alabama. W-2661.

DESIGNING-DRAFTSMAN. Must have good all-round experience on board and be able to make good clean presentation of ideas on paper for development department of mechanical organization. No actual designing required. This opening presents splendid opportunity for the right man. Salary, $3600–$5000 a year. Permanent. Location, Connecticut. W-2664.

ASSISTANT EDITOR, 25–37, graduate mechanical engineer, with at least 3 years' experience in heating, ventilating, or air-conditioning work. Permanent with excellent chances for advancement for anyone with an interest in writing and editorial work. Salary, dependent upon experience, probably in neighborhood of $2000–$4000 a year. New York, N. Y. W-2667.

DEVELOPMENT ENGINEER, graduate mechanical, 40–48, with a well-rounded background in machine-tool design. Company has well-established product but wishes to develop for postwar business. Permanent. Salary open. Location, northern New York State. W-2675.

MECHANICAL ENGINEERS, over 38, with M.E. degree or equivalent in commercial training. Should be experienced in design of small machines and/or mechanical home appliances. Must be familiar with limitations of engineering processes necessary to fabricate components such as die castings, metal stampings, plastic molded parts, etc. A knowledge of the fundamentals of electricity would be desirable but is not essential. About $4800 a year depending upon qualifications. Pennsylvania. W-2680.

SUPERVISOR for methods and standards department. Man should have well-rounded background in time and motion study, methods, etc., but his forte should have been job evaluation and setting of piecework rates. Salary open. Connecticut. W-2685.

MECHANICAL ENGINEER with foundry and machine-tool experience. Postwar opportunity; permanent position for energetic, progressive engineer with pleasing personality and faculty for leading men in getting work accomplished. Company with several plants located in western Pennsylvania long-established and progressive. Position will lead to plant-production managerial work. Write giving full details of current and past experience, salaries, received, education, age, marital status, etc. W-2686.

SALES CONTACT ENGINEERS, preferably graduate mechanical. Should have complete knowledge of power-plant and heat-exchanger equipment. Should have acquaintances on Eastern-Seaboard area. Will cover territories from Boston to Virginia. Prefer men in the 30's, married, and willing to travel. Permanent. $3600–$4800 year. Headquarters, New York, N.Y. W-2692.

ENGINEER who has specialized in tool designing. Must be thoroughly familiar with machine-shop practice and machine construction. Must be experienced in automatic-screw-machine design and construction as well as turret lathes, milling machines, etc., and thoroughly experienced and qualified to design and tool any of these machines. Salary open. New York metropolitan area. W-2697.

ENGINEER who is thoroughly conversant in time and motion study. Must be highly experienced in machine-shop practices and should be experienced in taking time studies for the purpose of setting wage incentives. Salary open. New York metropolitan area. W-2698.

SALVAGE MANAGER for company having considerable number of plants. Work would consist of developing use for machinery, equipment, and materials found obsolete in one plant or, if not usable, disposing of same by sale. Must have similar experience. Permanent. Salary open. Headquarters, Virginia. W-2701-D-1588.

CHIEF INSPECTOR for machine-parts plant. Must be graduate mechanical engineer or have equivalent experience. Must know precision inspection routine and should have some previous inspection experience. About $6000 a year. Location, northern New Jersey. W-2702.

PUMP SALES MANAGER. Man should be familiar with marketing of domestic and farm water systems, deep- and shallow-well type, and with jobber and dealer trade. Should have vision and ability to institute successful sales programs with full knowledge of advertising media, attractive advertising copy, etc. $4000–$5000 year. Location, Middle West. W-2710-C.

FOUNDRY SUPERINTENDENT AND ASSISTANT FOUNDRY SUPERINTENDENT for large gray-iron carbon and alloy-steel foundry. Must have good practical background and also must be thoroughly experienced and qualified engineer. Foundry is set up on high-production basis with automatic molding, core-making, and sand-reclaiming apparatus. Plant employs 275 to 300 people. Permanent. Salary open. Pennsylvania. W-2726.

MAINTENANCE ENGINEER to direct all maintenance operation of two large plants. Will be fully responsible for plant-maintenance engineers. $6000–$8500 a year. Company also needs plant-maintenance engineers with good all-round experience in general machine and building maintenance practice. $5000–$6500 year. New York, N. Y. W-2729.

PLANT MANAGER for machine-tool plant doing high-production work on small parts and assembly work. Must be top-grade man with proved background and thorough knowledge of modern production methods. $7500–$10,000 year. New York metropolitan area. W-2731.

ASSISTANT CHIEF ENGINEER, about 35, graduate mechanical, to assist with general engineering work which is varied. Should be imaginative, i.e., able to think independently, and preferably with varied experience. Department consists of 12 to 15 persons. Ohio. W-2741-D.

INDUSTRIAL ENGINEER with considerable experience with machine-tool plant. Must thoroughly understand scheduling of work through operations and be able to assist chief planning engineer in methods, tools, etc. Permanent. $7200 a year. Northern New York State. W-2754.

(*A.S.M.E. News continued on page 760*)

A.S.M.E. Calendar

of Coming Meetings

October 28-29, 1943
Joint Meeting of A.S.M.E. Fuels and A.I.M.E. Coal Divisions
Pittsburgh, Pa.

November 29–December 3, 1943
A.S.M.E. Annual Meeting
New York, N. Y.

April 3–5, 1944
A.S.M.E. Spring Meeting
Birmingham, Ala.

June 19–22, 1944
A.S.M.E. Semi-Annual Meeting
Pittsburgh, Pa.

(*For coming meetings of other organizations see page 32 of the advertising section of this issue*)

1943 A.S.M.E. Memorial Biographies Sent on Request

MEMBERS of The American Society of Mechanical Engineers who wish to receive a copy of the 1943 Memorial Biographies of Deceased Members are requested to fill out and mail the accompanying form, or order by letter, addressed to the Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

These Memorial Biographies, which will be published in October, will form a part of the Society Records Section of the Transactions as bound for library use.

A.S.M.E.
29 West 39th St.
New York, N. Y.

Please send me a copy of the October, 1943, issue of Memorial Biographies.

NAME.....

ADDRESS.....

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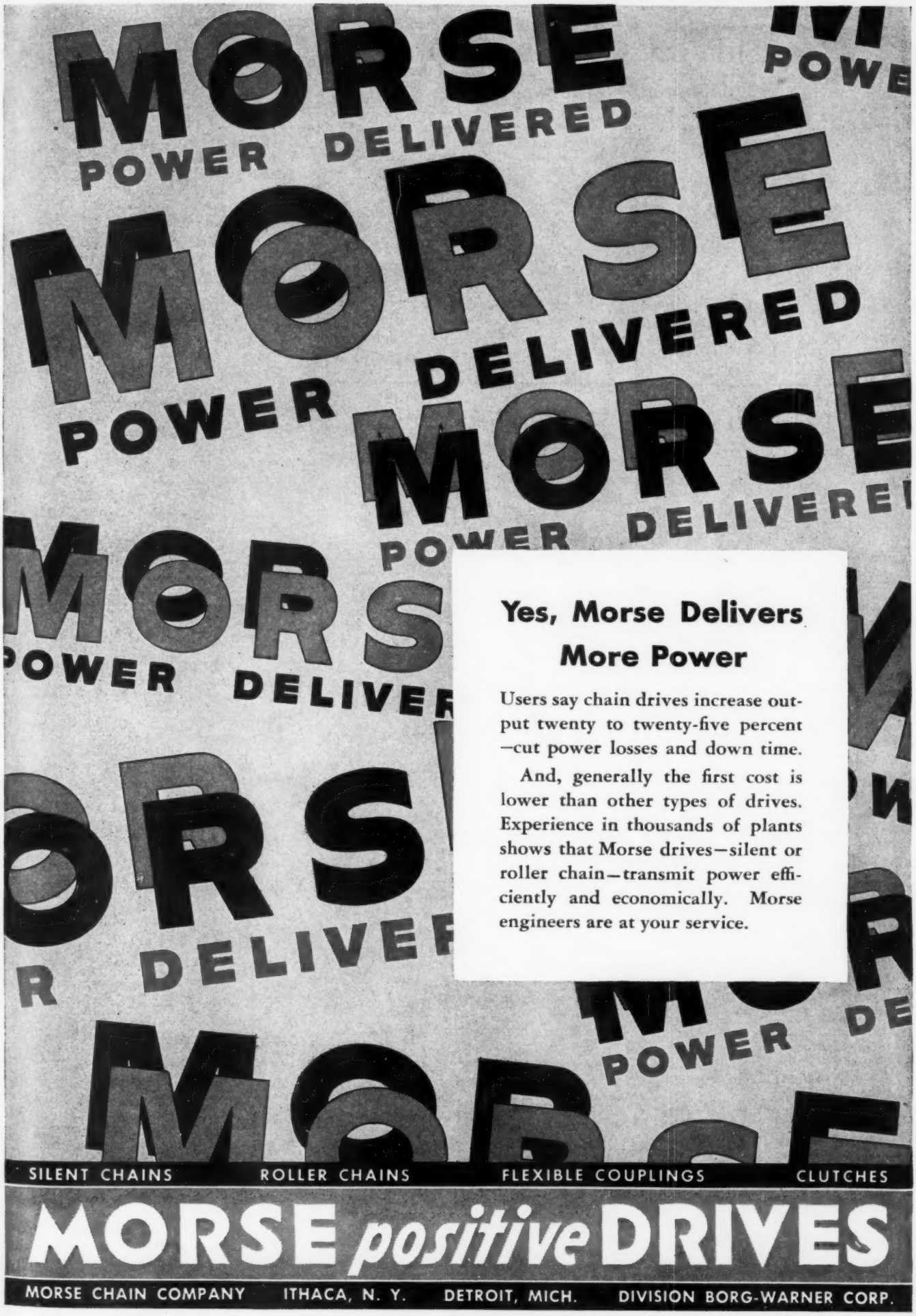
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R. A. Haines, A.S.M.E. Junior Member, Honored Posthumously

THE Navy Cross has been awarded posthumously to Lieutenant Richard A. Haines, U.S.N.R., junior member A.S.M.E. The citation reads:

For extraordinary heroism as assistant to the Damage Control Officer during action against enemy Japanese forces off Savo Island on the night of November 30, 1942. When his ship was struck by a torpedo forward, Lieutenant Haines, with utter disregard for his own personal safety, remained at Central Station to assist in the control of damage until he finally succumbed to an asphyxiating gas which had been generated by the explosion. His courageous spirit of self-sacrifice, maintained above and beyond the call of duty, was in keeping with the highest traditions of the United State Naval Service. He gallantly gave up his life in the defense of his country.

For the President,
FRANK KNOX
Secretary of the Navy

On August 26, 1943, Mrs. R. A. Haines, at the invitation of the Secretary of the Navy, sponsored the launching of the destroyer escort U.S.S. *Haines* from the ways of the Consolidated Steel Corporations shipbuilding division.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after October 25, 1943, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the Secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

ANDERSON, NILES M., Ontonagon, Mich.
ARONOFF, DANIEL J., Berkeley, Calif.
AYRES, RICHARD, Dallas, Tex.
BAKER, HARRY D., Natick, Mass.
BAKER, STANLEY V., Baltimore, Md.
BANDEKOW, RICHARD J., Middle River, Md.
BARNEY, JEROME, Bethlehem, Pa.
BATES, MAURICE E., Princeton, N. J.
BLEIER, FRANK P., Chicago, Ill.
BOTTS, EARL A., Washington, D. C. (Rt)
BRAND, RONALD S., Troy, N. Y.
BROWN, FRANK L., Lawrence, Kans.
BROWNE, EDMUND V. (Lieut.), Springfield, Mass. (Re)
CAINE, F. J. (CAPT.), Hoylake, Wirral, England (Rt & T)
CARD, LAWRENCE B., Denver, Colo.
CHILDS, J. N., Philadelphia, Pa. (Rt)
CHOYCE, NICHOLAS B., SR., Jackson Heights, N. Y.
COOKE, G., Germantown, Pa. (Rt & T)
CUMMINS, ANDREW A., Ann Arbor, Mich.
DUBLAN, STERLING R., Weeks, La.
DURLAND, ARTHUR C., Sunnyvale, Calif.
FLORSCHUTZ, F. E., Pittsburgh, Pa.
FORT, TOMLINSON, Wilkinsburg, Pa.
FRAHER, BRENDAN J., Philadelphia, Pa.
FRAME, J. WARREN, 3RD, Hartford, Conn.
GIBSON, WM. A., Redfern Sydney, Australia (Rt & T)
GILL, H. V., Winslow, Ariz.
GORDY, GEO. B. JR., San Jose, Calif.
GRAHAM, PAUL S., Pittsburgh, Pa.
HAHN, MANUEL, Winnetka, Ill. (Rt)
HAJEWSKI, CYRIL M., Detroit, Mich. (Re)
HAWKINS, ROBT. B., Muskegon, Mich.
HAWTHORNE, CHAS. W., JR., Upland, Calif.
HEMINGWAY, EVERARD L., Elkhart, Ind.
HERTZ, DAVID B. (LIEUT.), Annapolis, Md.
HEYMSFIELD, HERBERT, Brooklyn, N. Y.
IP, CHING-U, Cambridge, Mass.
JAMES, C. WRIGHTMAN, Toronto, Ont. Can.
JOHNSON, GEO. A., Detroit, Mich.
JUDD, CHAS. M., Cincinnati, Ohio
KENYON, VAN L., JR., S. Burlington, Va.
KERBY, W. D., JR. (LIEUT.), New York, N. Y.
LEACH, J. L., Rochester, N. Y.
LESSMANN, GERHARD P., Pittsburgh, Pa.
MARROW, CHAS. E., Altadena, Calif.
MEYER, ARTHUR E., Los Angeles, Ca'if.
MITCHELL, HARRY, Whitinsville, Mass.
MORRELL, LESTER W., Washington, D. C.
MORSE, RALPH L., Newton Centre, Mass.
NAUJOKS, WALDEMAR, Cleveland, Ohio
NIXON, STUART, Muskegon, Mich.
OTTEN, HENRY, New York, N. Y.
PHILLIPS, T. I , Pittsburgh, Pa.
POWELL, CHAS. A., East Pittsburgh, Pa. (Rt)
POWELL, E. M., York, Pa.
PURINTON, DEXTER J., Rutherford, N. J. (Rt)
PURKAYASTHA, P. B., Assam, India
READY, RAY C., Portland, Oregon
ROSS, GRANT D., Ontonagon, Mich.
SACHS, GEO., Cleveland, Ohio
SADOWSKY, MICHAEL A., Chicago, Ill.
SCHWARTZ, K. W., New York, N. Y.
SCOTT, CHAS. S., Toronto, Ont., Can.
SENGSTAKEN, C. W., New York, N. Y.
SHAFER, MAURICE, New Rochelle, N. Y.
SHOEMAKER, WM. M., Kennett Square Pa.
SYROVY, GERALD H., Philadelphia, Pa.
VIOHL, CHRISTIAN W., JR., Wilmington, Del.
WARNER, RUSSELL G., New Haven, Conn.
WATERMAN, EDWIN S., St. Louis, Mo.
WHITE, TRESCOTT S., San Francisco, Calif.
WIMAN, CHARLES DEERE (COL.), Washington, D. C.
ZIEGLER, LESTER W., Kitchener, Ont., Canada

CHANGE OF GRADING

Transfer to Fellow

STEVENS, C. C., Bristol, Conn.

(*Continued in next column*)

Transfers to Member

BURMESTER, L. R., Buffalo, N. Y.
FAIRMAN, STANLEY, Corning, N. Y.
HINNANT C. H., JR., (CAPT.), Ft. Meade, Md.
KIMBROUGH, J. C. (LIEUT.), Detroit, Mich.
LANGHAM, HENRY T., New York, N. Y.
MORO-LIN, JOSEPH J., New York, N. Y.
POTTER, JAS. H., Baltimore, Md.
SCHMIDT, FREDK. W., Brooklyn, N. Y.
SCHUELER, LYLE B., Westfield, N. J.
SOLING, SAM P., York, Pa.
SPORLEDER, EDMUND O., St. Louis, Mo.
SYMON, MAXWELL S., New York, N. Y.

Necrology

THE deaths of the following members hav recently been reported to headquarters:

CONRAD, HUGH V., August 17, 1943
EVERITT, FRANK C., August 4, 1943
HILL, REUBEN, August 15, 1943
MANTIUS, OTTO, April 30, 1943
MESSICK, GEORGE B., March 29, 1943
PAYNE, FRANCIS H., November 10, 1942
PETERSON, JOHANN G., July 26, 1943
ROSENCRANTS, FAY H., August 27, 1943
SCHRANZ, CHARLES A., March 22, 1943
UEBE, ERNEST K., August 5, 1943
VARNES, WILLIAM W., July 30, 1943

A.S.M.E. Transactions for September, 1943

THE September, 1943, issue of the Transactions of the A.S.M.E., which is the *Journal of Applied Mechanics*, contains:

TECHNICAL PAPERS

Stress Distributions in Cylindrically Aeolotropic Plates, by G. F. Carrier
A Table of Thermodynamic Properties of Air, by Joseph H. Keenan and Joseph Kaye
Temperature Relations in Journal-Bearing Systems, by M. Muskat and F. Morgan
On Cutting and Hobbing Gears and Worms, by D. W. Dudley and H. Poritsky
The Strength of Cylindrical Dies, by G. Sachs and J. D. Lubahn
Photoelastic Separation of Principal Stresses by Oblique Incidence, by D. C. Drucker
A Numerical Procedure for the Calculation of the Moments in Edge Reinforcements of Cutouts in Monocoques, by N. J. Hoff
The Free Lateral Vibrations of a Cantilever Beam With a Terminal Dashpot, by E. J. McBride

DESIGN DATA

Design Data for Flat Circular Plates With Central Holes, by W. E. Trumpler, Jr.

DISCUSSION

On previously published papers by A. M. Wahl and E. G. Fischer; B. F. Langer and F. H. Lamberger; L. S. Rhodes

BOOK REVIEW